SAARC Workshop on

DROUGHT Risk Management in South Asia

8-9 August, 2010, Kabul, Afghanistan

SAARC

Organised by

SAARC Disaster Management Centre, New Delhi

In collaboration with

Afghanistan National Disaster Management Authority

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Islamic Republic of Afghanistan

جمهوری اسلامی افغانستان

Mohammad Karim Khalili
Second Vice President

شماره :

تاریخ :

Message

First and foremost I would like to present my gratitude to SAARC, Afghanistan National Disaster Management Authority and its partners for conducting the Drought Risk Reduction Workshop a very precious event in Kabul, Afghanistan. Certainly such workshops are valuable steps toward disaster preparedness, awareness and response at country level.

Unfortunately, Afghanistan has always been prone to natural disasters. Floods, drought, sandstorms and earthquakes as well as extreme winters have been the most common disasters in the country, causing loss of lives and property, and wide spread displacing people. Years of conflict, high levels of poverty and unemployment, environmental degradation and poor infrastructure have increased the vulnerability of the people. The most important element in this context is to be prepared and how to respond to such disasters.

Furthermore, awareness of the disaster and preparedness will play a significant role in reducing the level of vulnerability and will lead us for sustainable development.

Indeed, scientific knowhow supports a country for being aware and respond to natural disasters, as well as experiences, lessons learnt, and best practices of the region would have its obvious impact for reducing the risk.

The Afghan economy continues to be overwhelmingly agricultural. Agricultural production is constrained by an almost total dependence on erratic winter snows and spring rains for water; irrigation is primitive. Relatively little use is made of machines, chemical fertilizer, or pesticides. Therefore, the impact of drought is very high throughout Afghanistan which is rendering people's lives. As such holding such workshops is really helpful.
I hope the workshop on drought risk reduction will have significant achievements, and While we embark on of this important event, I urge all the distinguished participants to provide their valuable inputs and guidance for successful mechanism on drought risk reduction. I also take this opportunity to thank all participants of the workshop.

Mohammad Karim Khalili
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Islamic Republic of Afghanistan

Afghanistan National Disaster Management Authority (ANDMA)

جـــمهوری اسلا مــــی افغانستان

اداره ملی آماده گی مبارزه با حوادث

ریاست پالسی وانسجام

امریت روابط بین المللی

شماره :

تاریخ :

MESSAGE

It's a pleasure to express my warm greetings to the honorable members of SAARC, participating in Regional workshop on Drought Risk Management, which taking place in Kabul, Afghanistan. 8-9 august 2010.

Afghanistan is mountainous and very dry country located in the arid sub – tropical at 9 – 37 north of the equator. Afghanistan has an arid and semi- arid continental climate with cold winters and hot summers. The lowland plains in the south of Afghanistan experience extreme seasonable variations in temperature, with average summer; June, July and August, temperatures exceeding 38 C and mean winter December, January and February temperature of around 10 C.

Afghanistan is currently suffering the most severe drought in living memory. The country is characterized by large areas with little to no precipitation; that which does occur falls mostly as snow on high mountains from winter storms (of a Mediterranean origin) between November and April with peaks in February/March. The snow season varies considerably with elevation. The Asian summer monsoon system helps to keep rainfall low over Afghanistan. Dust storms are a significant part of the climate system associated with northerly winds in warm months.

Drought is a major disaster threat in Afghanistan. Every year, about one hundred thousand to half a million Afghans are affected by drought alone. The economic impact of drought in Afghanistan is beyond our imagination. Every year, the Government of Islamic Republic of Afghanistan has to provide huge amount of our scare financial resources to drought victims in the country. This has severely limited our development activities and competes with other priority needs in Afghanistan.

As drought is a slow onset disaster, if we have an effective early warning system and good road map to mitigate its negative impact, we are confident that we can minimize its affect in the region and countries. Therefore, we believe that regional level workshop as this and the regional road map will immensely help to achieve our objective of minimizing the negative impact of disaster in each country of the region.

Afghanistan is committed to fulfill its commitments and support in implementing any activities that enhances the regional cooperation and support in the field of drought management in particular and disaster management in general.

It is indeed a great proud for the people of Afghanistan to host this SAARC regional workshop on Drought Risk Management in Kabul, from 8 – 9 August 2010. On behalf of the government and people of Afghanistan, I would like to welcome you all in Afghanistan and wish a very successful regional workshop.

Dr. Abdul Matin Adrak

General Director

SAARC DISASTER MANAGEMENT CENTRE, NEW DELHI

P. G. Dhar Chakrabarti
Director

8 August 2010

Historically disaster management in South Asia began with management of droughts. Successive droughts and the resultant famines that killed millions impelled the colonial administration to develop famine codes that became the basis of relief manuals in post independent era. Large scale improvement of agriculture and irrigation in many areas and diversification of economy in the recent decades have blunted the impact of drought at the macro level, but periodic drought still remains the most creeping and devastating disaster which affects millions of rural communities of South Asia. The climate change and its impact on water and agriculture are bound to further worsen the drought situation of the sub-continent in the years and decades to come.

Every country of South Asia has centuries of experience of dealing with droughts. Most of these experiences have not been documented and have almost gone into oblivion. What is even more unfortunate is that each country has so far largely worked in isolation without much motivation to look beyond to find out what their neighbours have been doing, whether there are good practices that are worthy of emulation and whether there areas of common concern that can be better addressed by regional collaboration. Surely time has come to break this logjam and establish channels and networks of communication among scientists, policy makers and practitioners in the countries of the region to interact and share knowledge and good practices, develop regional early warning systems of drought, organize trainings and workshops and establish joint regional projects of drought mitigation and preparedness that will be of mutual benefit to the countries and communities of the region.

The SAARC Workshop on Drought Risk Management organised by the SAARC Disaster Management Centre New Delhi, in collaboration with the Afghanistan National Disaster Management Authority on 8-9 August 2010 in Kabul is probably the first ever attempt to hold a regional consultation on drought risk management in South Asia. The workshop has the challenging task of developing the blue print of a commonly agreed road map for regional cooperation on drought risk management on the basis of which projects of regional collaboration for short, medium and long term period shall be prepared.

Surely this would be a historic opportunity to understand the challenges and perspectives of each country, assess the mutual strength and weaknesses, and develop a framework for working together to address issues of drought management that are regional in nature and would that would benefit the people of the entire region.

(P.G.Dhar Chakrabarti)

Drought Risk Management in South Asia

SAARC Disaster Management Centre, New Delhi

Drought – A Global Perspective

Drought is one of the major threats among natural hazards to people's livelihoods and socio-economic development. Drought tends to occur less frequently than other hazards; however, when it does occur, it generally affects a broad region for seasons or years at a time. As per the global database of disasters maintained by the Centre for Research on Epidemiology of Disasters, Leuven drought accounted for only 4.2% of the total natural disaster events (428 out of 10,186 disasters) during the past four decades (1970-2009). Africa had the maximum number of droughts, as also the maximum deaths due to droughts, but Asia suffered the maximum economic loss as also the maximum number of persons affected due to droughts.

Table-1 *: Continental Contrasts - Impact of Drought - 1970-2009*

	No. of Events	Total Killed	Average killed	Total Affected	Average Affected	Damage (000 US$)
Africa	184	553095	3006	266806719	1450037	4816693
Americas	97	77	1	47203120	486630	15432539
Asia	100	5308	53	1292962442	12929624	27619641
Europe	34	2	0	10482969	308323	18561309
Oceania	13	60	5	7987635	614433	10103000
Total	428	558542	1305	1625442885	3797764	76533182

Source *: EM-DAT, Centre for Research on Epidemiology of Disasters, Leuven*

Drought comprises of nearly 18% of all natural disasters of Africa, 4.5% in Oceania, 4% in Americas and 3.5% in Asia and Europe, but the percentage of persons affected by drought far exceeded their numbers in all the continents.

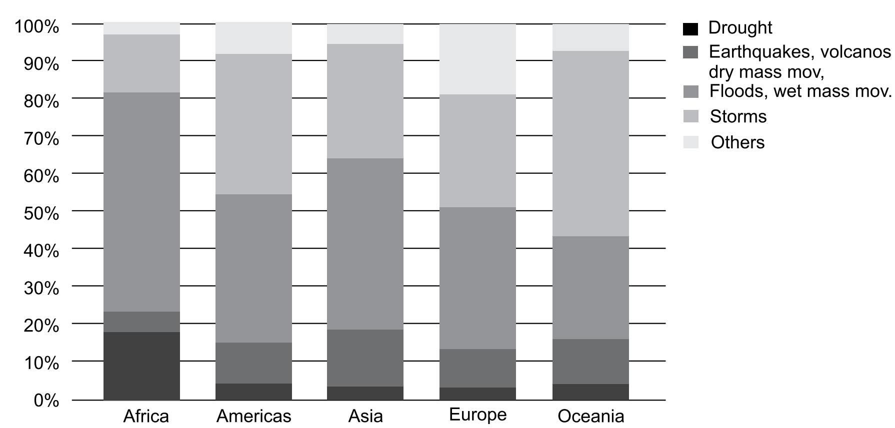

Figure 1 *: Proportion of Disaster Occurrence by Continent 1970-2009*

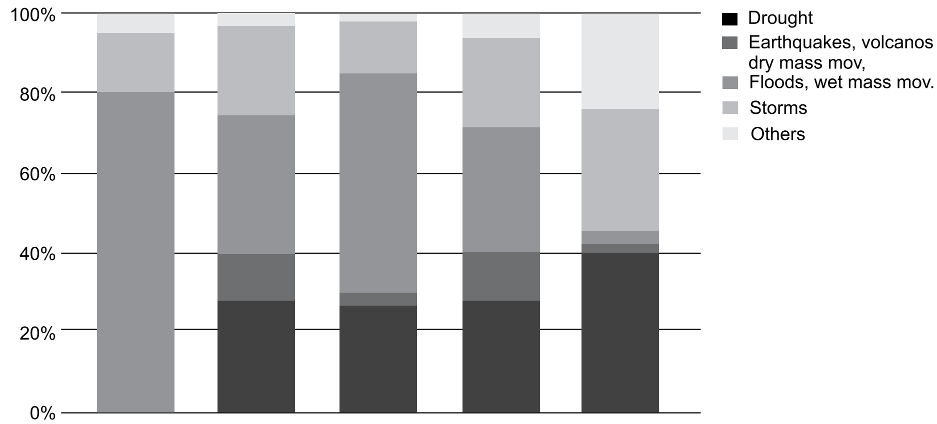

Figure 2 : *Proportion of Persons Affected by Disasters by Continent 1970-2009*

Almost every country of the globe, except parts of Northern America and Eastern and Central Europe, is affected by droughts of varying magnitudes. Country wise spread of drought is shown in figure 3. Each country differs in its capacity to effectively prepare for and respond to the effects of drought. Therefore, the number of people affected by drought and the types of impacts experienced vary widely. In the Asian region, in particular, India and China recorded the largest number of people affected by drought from 1970 to 2009. However, for the same period, it was Africa that recorded the largest number of peopled killed due to the catastrophic droughts in Ethiopia, Sudan and Mozambique in the 1980s. Disasters triggered by prolonged drought in developing countries can severely harm countries' development, affect millions of people and contribute to malnutrition, famine, loss of life and livelihoods, emigration and conflict situations; whereas droughts in developed countries primarily result in economic losses.

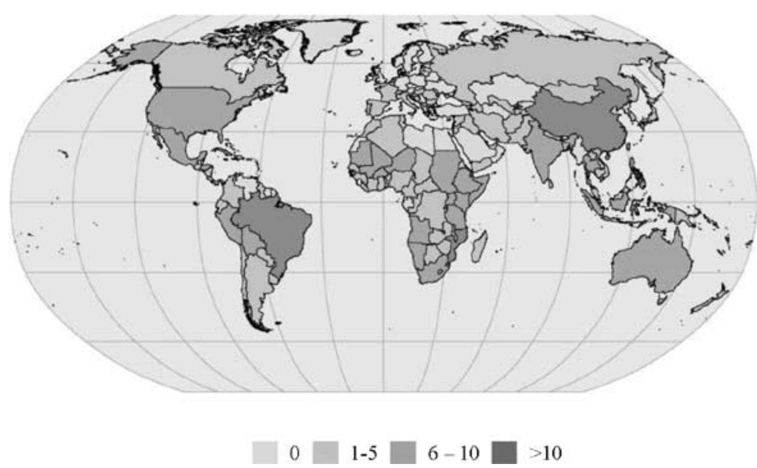

Figure 3 : *Number of Drought Disasters Reported by Country 1970-2009*

Every projection indicates that the incidence of drought would increase with global warming and its impact worsens particularly in the developing countries. There have been at least four different but interrelated global initiatives to reduce the risks of drought and to combat the effects of drought on the life and livelihood of the people. The first is the UN Convention to Combat Desertification (UNCCD) of 1994 which is rooted in a Plan of Action to Combat Desertification, adopted by the United Nations Conference on Desertification in 1977. As of

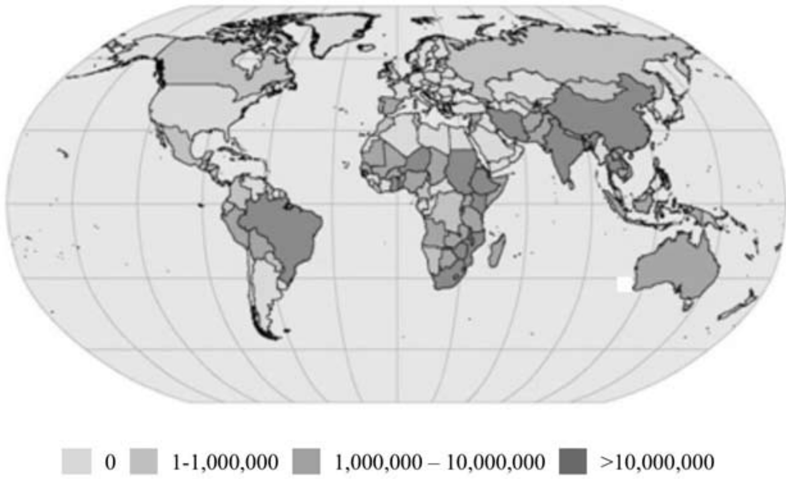

***Figure 4** : Number of Persons Reported Affected by Drought 1970-2009*

31 December 2009, the Convention had 193 country Parties. The eighth session of the Conference of the Parties (COP 8) held in Madrid, Spain, in June 2007, adopted a 10-year strategic plan and framework to enhance the implementation of the Convention (2008-2018) and effectively combat desertification. The strategic plan will operate through five specific objectives: 1) advocacy, awareness-raising and education, 2) enhanced policy framework, 3) science and technology, 4) capacity building, and 5) financing and technology transfer. In addition, roles and responsibilities of the various UNCCD institutions, partners and stakeholders have been reshaped, including those of the Committee on Science and Technology (CST), the Committee for the Review of the Implementation of the Convention (CRIC), the Global Mechanism (GM) and the UNCCD secretariat.

Drought risk reduction is also connected with the UN Framework Convention on Climate Change (UNFCCC). The UNFCCC encourages the Parties to cooperate in preparing for adaptation to the impacts of climate change and to develop appropriate plans for various areas including water resources, agriculture and rehabilitation of regions affected by drought and desertification. The Bali Action Plan that was agreed by the UNFCCC Thirteenth Conference of the Parties, held in Bali, Indonesia, 3-14 December 2007call for enhanced action on adaptation through consideration of:

- Risk management and risk reduction strategies, including risk sharing and transfer mechanisms such as insurance;
- Disaster reduction strategies and means to address loss and damage associated with climate change impacts in developing countries that are particularly vulnerable to the adverse effects of climate change.

The Convention on Biological Diversity (CBD), administered by UNEP, provides another relevant framework for drought risk reduction. In particular, its programmes on Dry and Sub-humid Lands Biodiversity and Traditional Knowledge, Innovations and Practices, offer valuable expertise and networks to promote and support the objectives of drought risk reduction.

The United Nations International Strategy for Disaster Reduction (UNISDR) created an Ad Hoc Group on drought which brought together prominent scientists and practitioners from a variety of institutes and UN agencies. The initiative resulted in an integrated approach to reducing societal vulnerability to drought, which has been used to promote drought-resilient nations and communities around the world. Subsequently, the second World Conference on Disaster Reduction was held in Kobe, Hyogo, Japan, in January 2005, where governments adopted the Hyogo Framework for Action 2005-2015: Building the Resilience of Nations and Communities to Disasters, which outlines five priorities to build resilience of nations and communities to natural hazards. Based on these five priorities, the UNISDR developed Drought Reduction Framework and Practices in 2009 which provides a most comprehensive framework for reducing the risks of drought.

Definition and Typology of Drought

Drought is a natural part of climate, although it may be erroneously considered as a rare and random event. Drought differs from aridity, which is restricted to low rainfall regions; it can occur in any climatic zone, but its characteristics vary significantly from one region to another.

A broad definition of drought is a deficiency of precipitation over an extended period of time, usually a season or more, which results in a water shortage for some activity, group, or environmental sectors. However, in terms of typologies, droughts are classified as meteorological, agricultural, hydrological, and socio-economic.

Meteorological drought is usually defined by a precipitation deficiency over a pre-determined period of time. The thresholds chosen, such as 50 percent of normal precipitation over a six-month time period will vary by location according to user needs or applications.

Agricultural drought is defined more commonly by the lack of availability of soil water to support crop and forage growth than by the departure of normal precipitation over some specified period of time. The relationship between precipitation and infiltration of precipitation into the soil is often not direct. Infiltration rates vary depending on antecedent moisture conditions, slope, soil type, and the intensity of the precipitation event. Soil characteristics also differ. For example, some soils have a higher water-holding capacity, which makes them less vulnerable to drought.

Hydrological drought is normally defined by deficiencies in surface and subsurface water supplies relative to average conditions at various points in time through the seasons. Like agricultural drought, there is no direct relationship between precipitation amounts and the status of surface and subsurface water supplies in lakes, reservoirs, aquifers, and streams because these hydrological system components are used for multiple and competing purposes, such as irrigation, recreation, tourism, flood control, transportation, hydroelectric power production, domestic water supply, protection of endangered species, and environmental and ecosystem management and preservation. There is also a considerable time lag between departures of precipitation and the point at which these deficiencies become evident in surface and subsurface components of the hydrologic system.

Socio-economic drought differs markedly from the other types of drought because it reflects the relationship between the supply and demand for some commodity or economic good (such as water, livestock forage, or hydroelectric power) that is dependent on precipitation. Supply varies annually as a function of precipitation or water availability. Demand also fluctuates and is often associated with a positive trend as a result of increasing population, development and other factors.

The relationship between these types of drought is illustrated in Figure 5. Agricultural, hydrological and socio-economic drought occurs less frequently than meteorological drought because impacts in these sectors are related to the availability of surface and subsurface water supplies. It usually takes several weeks before precipitation deficiencies begin to produce soil moisture deficiencies leading to stress on crops, pastures, and rangeland. Continued dry conditions for several months at a time bring about a decline in streamflow and reduced reservoir and lake levels and, potentially, a lowering of the groundwater table. When drought conditions persist for a period of time, agricultural, hydrological and socio-economic drought occur, producing associated impacts. During drought, not only are inflows to recharge surface and subsurface supplies reduced, but demand for these resources increases dramatically as well.

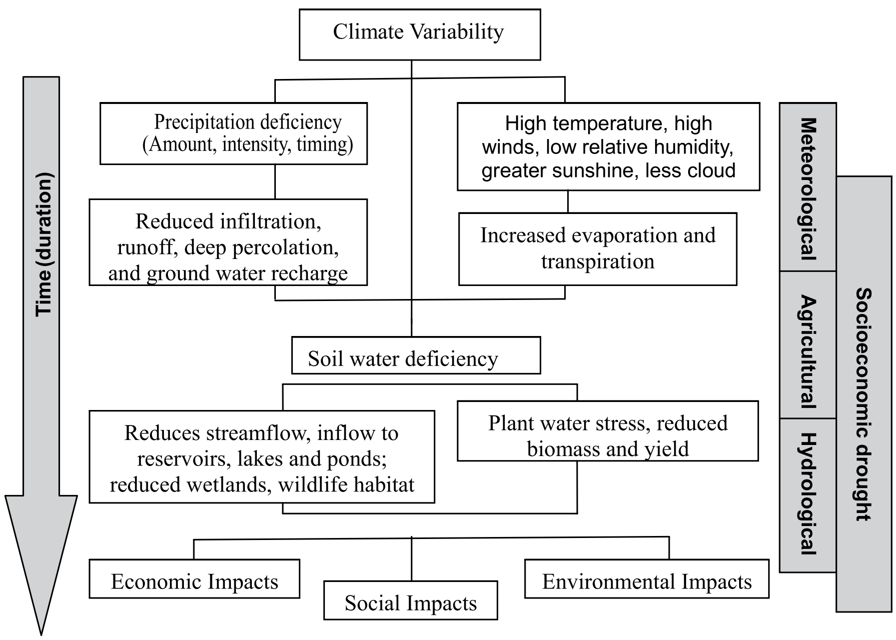

***Figure 5** : Relationship between Meteorological, Agricultural, Hydrological and Socioeconomic Drought*

***Source**: National Drought Mitigation Centre, University of Nebraska, USA*

The direct linkage between the main types of drought and precipitation deficiencies is reduced over time because water availability in surface and subsurface systems is affected by how these systems are managed. Changes in the management of these water supplies can either reduce or aggravate the effects of drought. For example, the adoption of appropriate tillage practices and planting more drought-resistant crop varieties can diminish the effect of drought significantly by conserving soil water and reducing transpiration. Therefore, the effects of drought are a product of both the physical nature of the hazard and our ability to manage risk.

Drought does not automatically lead to a disaster. Disaster only occurs when there is a serious disruption of the functioning of a community or a society, which involves widespread human, material, economic or environmental losses and impacts, which exceeds the ability of the affected community or society to cope using its own resources. These potential disaster losses, in lives, health status, livelihoods, assets and services, which could occur to a particular community or a society over some specified future time period, are defined as "disaster risk". Drought risk management is "the systematic process of using administrative directives, organizations and operational skills and capacities to implement strategies, policies and measures for improved coping capacities in order to lessen, i.e., prevent, mitigate and prepare for, the adverse impacts of drought and the possibility of disaster".

Understanding Drought Risk and Vulnerability

The risk associated with drought for any region or group is a product of the exposure to the natural hazard and the vulnerability of the society to the event. Exposure to drought varies regionally and over time, and there is little, if anything, that can be done to alter its occurrence. However, it is critically important for scientists to understand and communicate the probability of drought events of various levels of intensity and duration. It is also essential to understand precipitation and temperature trends, including changes in variability, because these key meteorological variables may indicate potential changes in the frequency and severity of future drought episodes.

In 2007,the Intergovernmental Panel on Climate Change (IPCC) released the report "Impacts, Adaptation and Vulnerability", as a part of its Fourth Assessment Report "Climate Change 2007".The report confirms that our atmosphere is warming, a trend that will have an impact on the frequency and severity of some natural hazards, such as drought. The report notes that recent climate changes and variations are beginning to affect many natural and human systems. For example, in the Sahel region of Africa, warmer and drier conditions have led to a reduced length of the growing season, with detrimental effects on crops. In southern Africa, longer dry seasons and more uncertain rainfall are prompting adaptation measures. The report also notes that drought- affected areas will likely increase in extent. Climate change is, therefore, an important factor to be considered in drought risk analysis.

Drought by itself does not trigger an emergency. Whether it becomes an emergency or not depends on its effect on local people, communities and society, and this, in turn, depends on their vulnerability to the stress of the drought.

People's vulnerability to drought is complex. Drought results in substantial effects in both developing and developed countries, but the characteristics of these effects differ considerably. The ability to cope with drought also varies considerably from country to country and from one region, community, or group to another. Therefore, a vulnerability profile, including analysis of vulnerability factors, is an invaluable tool in assessing local risk. The vulnerability profile is in fact the cornerstone of drought risk reduction planning.

A complete vulnerability analysis requires an assessment of both the macro and micro contexts. For example, the effect of drought in southern Africa must consider the context of violent conflict in some areas, major health crisis in the form of the HIV/AIDS pandemic and deepening poverty in many parts of the region. Added to this are well-documented cases of damaging policies, such as the mismanagement of strategic grain reserves and slowness in international relief operations. This macro context has resulted in large numbers of people who are now more vulnerable to the drought than they were ten years ago.

To understand what is happening at the micro level requires an understanding of local livelihoods and of coping strategies and capacities. How diverse and drought-resistant are local people's livelihoods? How strong is their asset base to tide them over during a prolonged period of drought? What claims can the most vulnerable groups make on those groups that are not as vulnerable? Understanding these dynamics is essential in understanding vulnerability, the likely effect of drought and appropriate responses.

One way to better understand vulnerability is through a livelihoods approach, especially if it captures both macro and micro factors and long-term trends that affect vulnerability and the impact of short-term shocks. Much work has been done by operational agencies and by researchers to develop various livelihoods frameworks, to make sense of the complex ways in which individuals, households, and communities achieve and sustain their livelihoods, and the likely impact of an external shock such as drought on both lives and livelihoods. The essence of a livelihoods approach is that it puts people at the centre of the analysis and is cross-sectoral, taking into account economic, political and cultural factors. Understanding the asset base is also crucial, including physical assets such as land and livestock, human capital and social capital. Generally speaking, the stronger and more diverse the household's asset base, the more drought-resilient it is likely to be and the greater its ability to switch between different livelihood strategies.

Overall, drought risk assessment must consider both an improved understanding of the natural hazard and human exposure to this climatic extreme, as well as a better understanding of the micro and macro context of people's vulnerability to drought. With this understanding, enhanced drought mitigation, preparedness, and response measures can be identified and implemented to create a more drought resilient society.

Drought in South Asia

Of all the SAARC countries, India is most affected by drought, especially in terms of the number of people it affects. In India, areas prone to drought are characterized by low annual rainfall (approx. 750 mm) with high evaporation, high variation in annual rainfall, and lack of assured water availability. The hardcore drought prone areas of the country comprise about 16 per cent of the geographical area and account for 11 per cent of the country's population.

The Irrigation Commission in 1972 identified two types of areas: drought prone and chronically drought prone. Drought prone areas are those with 20 per cent probability of rainfall deficiency of more than 25 per cent of the normal rainfall. Regions included in this category are Gujarat, east Rajasthan and adjoining parts of Punjab, Haryana, west Uttar Pradesh, west Madhya Pradesh, middle portion of Maharashtra, interior areas of Karnataka, Rayalaseema and South Telengana regions in Andhra Pradesh, parts of Tamil Nadu, a small portion of northwest Bihar and adjoining east Uttar Pradesh, and a small portion of northeast Bihar and adjoining portion of West Bengal. Chronically drought affected areas are those which have a 40 per cent probability of rainfall deficiency of more than 25 per cent of the normal rainfall. They cover the western parts of Rajasthan and the Kutch region of Gujarat.

In Pakistan, the effect of drought has been controlled through its massive canal network. But in some areas, drought remains chronic with substantial consequences in sectors of food security, livestock, agriculture, water resources and employment. About 60% of the total land area of Pakistan is classifies as arid, which annually receives less than 200 mm rainfall. The main arid rangelands include Cholistan, D.G.Khan, D.I.Khan, Kohistan, Tharparkar and Western Baluchistan. Average annual precipitation in Baluchistan and Sind provinces is about 160 mm. Rainfall variability during different seasons is also considerably high. Some areas remain drastically dry in each season and are always vulnerable to drought. Certain areas experience two-three drought years in every decade.

While Bangladesh is free from annual aridity, there is an existence of seasonal aridity of a maximum of six months in the north-western parts to a minimum of four months in the north-eastern parts. Drought is, thus, a temporary, spatially irregular and non-periodic phenomenon affecting small parts of Bangladesh. While only the Chittagong region is completely drought free, except for its southern tip, Bogra and Noakhali have the maximum number of drought years. Drought conditions in Bangladesh vary from region to region reaching from the lowest in Rajshahi region to the highest in Sylhet region.

In Bangladesh, a drought year is identified when more than 20 per cent area of the country is affected by drought. Bangladesh has never been wholly affected, in any drought year from 1949 to 1979. The highest percentage of area and population affected by drought occurred in 1957 -- 46.54 percent and 53.03 per cent, respectively. In the recent past, the severe drought years have been 1965-66, 1972-73, 1978-79, 1982-83 and 1989-90. Of these, the 1978-79 drought affected the whole country, whereas in other years' drought was more or less localised.

In Nepal, there is an adequate systematic microclimatic monitoring of information in the different ecological zones. Though a vast network of rivers has created favourable groundwater conditions, particularly in the Terai, drought conditions have been known to prevail in the Far Western Development Region of Nepal, where rainfall is insufficient as the monsoon arrives two to three weeks after it touches the eastern border of the country. Drought-like conditions have sometimes prevailed in all parts of the Terai because of inefficient irrigation systems. Insufficient irrigation at critical periods of cropping may induce drought-like conditions, and hot and dry conditions between March and May have been known to destroy standing crops.

In Sri Lanka, the dry zone is generally considered as the drought-prone area of the country. Based on an average annual rainfall, the country has been divided into three zones named as the Wet, Dry and Intermediate zones. Dry Zone has an average annual rainfall below 1900 mm; Intermediate Zone between 1900 mm and 2500 mm; and, Wet Zone between 2500 mm and 5500 mm. In the extreme northwest (in the Mannar Kalpitiya area) and in the extreme southeast (Yala area), the mean annual rainfall is below 1000 mm.

The long durations of major droughts are clearly felt and the losses which are experienced by their victims can be determined easily. But unlike the long droughts, short drought spells are less easily identifiable. These drought spells, if they occur at certain critical stages of agriculture, can have an adverse effect on production. Every year, somewhere in Sri Lanka, some people are always faced with droughts of short duration of local significance. Droughts of regional significance occur once in every 3-4 years and severe droughts of national significance occur irregularly. A severe drought occurred in 7 districts of the country in 2001 namely, Hambantotaa, Moneragala, Kurunegala, Puttalam, Rathnapura, Badulla and Ampara.

Effects of Drought in South Asia

Drought has a number of short and long term effects on the ecosystem of the affected area. Agricultural production in India is highly dependent on rainfall; hence, drought has a direct effect on it. Drought reduces the country's food grains production in certain years by as much as 15-20 per cent of the yield of a normal year.

Dryland agriculture in India has not been accorded the same importance as irrigated agriculture. The green revolution has further widened the gap between these two forms of agriculture. This is amply illustrated in the figures showing the production trend of main food grains. In the case of rice, the yield fluctuations are most severe. Some 60 per cent of the rice area in India is rainfed. This is also true for coarse grain and pulses, both of which are mostly grown in dryland areas. Wheat production is more stable because 65 per cent of the wheat crop in India is irrigated.

Most drought prone areas in India, particularly the arid districts, are endowed with reputed breeds of cattle & sheep. However, the productivity of livestock breeds is very poor in these areas due to loss of pasture lands, population explosion, absence of livestock feeds etc. Together with cattle, other milch animals such as buffaloes and goats are also severely affected due to shortage of drinking water and absence of fodder and feeds.

Prolonged drought has a direct impact on poverty. Impoverishment during droughts tends to be high in the absence of governmental intervention. When a drought strikes, the' first impact is on sowing. If thousands of acres are left unsown, wage earnings drop. This affects the incomes of agricultural labourers much before drought affects their food availability. Real incomes also tend to decline due to a rise in food prices following crop failure. This affects not only landless labourers but also small farmers. Sometimes a drought takes place after sowing is completed. As a result, farmers lose a large part of their investment. Increases in prices of commodities needed by the poor and decreases in prices of livestocks and other assets which the poor want to sell compound the adverse impact on the standard of living of the poor and their nutritional intake. This leads sometimes to mass migration from drought affected areas and disruption of normal family life of the people.

In the drought prone areas of Pakistan like Baluchistan, traditional systems of irrigation have been developed. Irrigation by karez tunnels depends ultimately on rainfall to recharge the aquifers or fill the nallas. In Quetta valley and parts of Makran, where groundwater is accessible, karez are dug from springs to lead the water to the valley floor. Long tunnels ate dug, with the help of shafts at 50 m intervals, to tap the ground water and maximize its flow to fields, gardens and orchards.

The southwest and northwest regions of Bangladesh are the country's predominantly drought prone areas. A study on the effect of drought on certain major crops in Bangladesh has revealed that 62 per cent of T. Aman yield reduction has occurred in Rajshahi, 50 per cent wheat yield reduction at Rajshahi, Bogra and Jessore, and 14-32 per cent of B. Aus yield losses are apprehended in a few districts due to drought. However, after studying soil, agronomic and meteorological data of over 20 years, it has been assessed that the national yield loss of crops like B. Aus, L.T. Aman and 8 HYV Aman are 12, 8 and 13 per cent, respectively. Since agriculture contributes around 50 per cent GDP of the country, this situation is a major factor contributing to its deteriorating economic situation. However, information on economic effects of drought and its impact on social changes are very scarce. Detailed studies have to be undertaken in this regard in drought prone areas.

The major feed resources in Bangladesh are fibrous residues from cereal crops and pasture or grasses. Both are usually low in nitrogen level and digestibility. A recent study has revealed that the intake of cattle feed per head per day for rice straw, green grasses and byproduct concentrates appears to be less than the standard feed requirement of cattle. But the availability of the concentrates and green grass is far less than the requirement. The drought situation aggravates the availability of all types of feed, including rice straw and green grass. Lack of required nutrients will ultimately affect production of milk and meat. The poor level of nutrition reduces the general immunity of the cattle. Consequently, cattle become more susceptible to various diseases. Poor economic conditions may compel farmers to sell their cattle for slaughter at a very nominal price, which will result in a reduction of draught and milch animals. This will have a direct impact on future crop production in the drought-affected areas and the country at large.

The main economic activities in the dry zone areas of Sri Lanka are irrigated paddy cultivation and dry land farming. The former is dependent largely on artificial reservoirs and the latter on rains. Prolonged drought in major paddy growing areas of Sri Lanka had caused a big decline in the 1988-89 and 2001-02 Maha crops leading to higher imports of rice as well as enhanced government relief expenditure to drought affected people. Nearly eight lakh people were affected in the North-Central, North-Western and Southern Provinces. Supporting services such as manufacture and repair of local agricultural equipment and tools, hiring of animals, carts and tractors, were severely affected and income opportunities of those engaged in support systems were reduced. Animal husbandry was also severely affected due to lack of fodder and wallowing water for buffaloes.

On the human side, acute food shortages are experienced by the majority of farmers who were poor and have no buffer stocks. A nutrition survey conducted in the southern part of the Anuradhapura district of Sri Lanka in 1979 showed that over 43 per cent children were chronically undernourished and 41 per cent of all housing units were diet deficient. And due to a poor diet, unsanitary conditions, and bad drinking water, large numbers of stunted children were found.

During May-September, there is an acute shortage of fodder in Sri Lanka. Livestock are among the first casualties in drought. In the Dry Zone, the traditional practice was to rear cattle and buffaloes in herds of 40. They are grazed in jungles in and around reservoir areas. However, in recent years, due to large- scale settlement schemes and intensive land use practices, these patterns are changing rapidly. In times of intensive drought when small reservoirs run dry, buffaloes are among the first to succumb to severe drought. There is an attendant loss in production of milk and other dairy products.

Farmers who run out of food reserves resort to borrowing for which land is kept as security. This generates a vicious circle leading the poorer farmers to stake all what they have and finally to lose the ownership of their land. Village level organizations, rural development societies and other socio- religious activities decline during periods of drought and famine. Children born during famines are physically retarded and some of them who have become permanently disabled may never be able to join the labour force.

Drought Risk Management in South Asia

During the colonial period, the sub-continent faced many droughts that turned into severe famines causing massive human losses. In the latter half of the 19th century, there were approximately 25 major famines across undivided India, which killed 30¬–40 million people. The first Bengal famine of 1770 is estimated to have wiped out nearly one-third of the population. The British developed Famine Code to provide relief and employment to the people, but that did not make much difference to the situation. The Bengal famine of 1943–44 killed nearly 4 million people. The situation improved remarkably in post-colonial era. A gradual but definite shift in approach from the post disaster relief and employment to pre disaster measures for agricultural development, irrigation facilities, drought proofing and watershed development made a huge difference. The green revolution in the 1960s made most of the countries of South Asia self-sufficient in food production, despite sharp rise in population. There have been years of drought which affected the livelihood of millions of people but famines were averted and the economy did not suffer the impact of drought in the same manner as it used to in the past. The countries have definitely achieved greater resilience to drought, but large areas of the sub-continent are still dependent on climate and rainfall for agriculture and millions of farming and grazing communities have been bearing the brunt of drought, and some areas chronically so, with serious consequences on livelihood, nutrition and general standards of living. There is huge scope for improving the policies and practices for drought risk management in the respective countries. There is even larger scope for regional cooperation and networking by sharing knowledge, information and good practices for better drought risk mitigation and management in the region.

The drought of 1978-79 shook the Bangladesh government and encouraged it to identify standing measures for drought management. The government's action followed through the formation of a national committee. A national drought management policy and programme was formulated in 1980 under the Ministry of Agriculture and Forests. The drought code prepared by the Ministry of Agriculture lays down the various actions that need to be taken to avert or fight drought. The steps envisage warning systems, and relief and rehabilitation. Both immediate and short term measures are enunciated. Long term measures, though not stated in the code, are being taken care of as the government is doing its best to extend irrigation facilities to all feasible areas.

Under the existing policy, the union council, at the lowest level, is responsible for primary information on drought, and to appraise the upzila parishad. The upazila parishad is then expected to mobilise all resources to fight the drought and apprise the district authorities. The district's deputy commissioner takes steps to tackle the situation and inform the national government. The secretary (agriculture and forests) takes all steps at the national level. Under short term measures, supply of drinking water and feed for livestock gets preference. To meet the demand of drinking water, if the ordinary tubewells fail, shallow tubewells, manually operated shallow tubewells or deepest shallow tubewells are installed. If necessary, the operation time of tubewells is rationed to ensure equitable water distribution in the locality.

The government has decentralised administration through the introduction of the upazila system. Food shortages are first brought to the notice of the upazila administration, which in turn informs the government. Food is supplied in the form of relief or food for work programmes. During a drought, economic activity declines. To ensure that the incomes of the poor are maintained, income generating activity has to be created. The government, together with NGOs, now plays a vital role by taking up digging of canals, reexcavation of derelict tanks, and repair and rebuilding of roads. The shortage of fodder becomes even more acute than human food at times of drought. So far there are no tangible means to tackle this problem. Loss of crop also causes a loss of fodder. Bangladesh has innumerable beels, haors, baors and swamps. These are often infested with water hyacinth and other aquatic plants which are eaten by cattle. These can supplement fodder requirements during distress periods. But these plants cannot meet the full requirement, if the drought continues for long.

Medium-term measures for maintaining production of food and fodder have been laid down in the "Drought Code" prepared by the Ministry of Agriculture and Forests in 1980 depending on the classes of land forms and soil types involved and available resources. Fortunately, both surface and ground water irrigation has increased considerably over the last decade.

Analysis of rainfall over Bangladesh shows that the minimum today rainfall over most of Bangladesh is nearly zero. This means that irrigation, as a long term measure, is necessary for crop growth. The current national objective is to attain self- sufficiency in food. Steps are, therefore, underway to extend irrigation facilities through optimum utilisation of water resources. Full scale irrigation development envisages barrages on the Ganga/Ganges and Brahmaputra. But these are a far cry due to various handicaps.

After the severe drought of 1978-79, momentum was generated to reexcavate canals, derelict tanks, dead river courses, make loop cuts, and create water reservoirs for agriculture and community needs. Due to policy changes, this programme has now been dropped. But drought prone areas of the country do require a programme of water conservation. The government is currently implementing the Integrated Barind Development Project. This programme aims at transforming the environment of the dry and almost denuded tree zones.

Forest and range lands are shrinking in Bangladesh at an alarming rate. The government has taken an afforestation programme covering 435 upazilas under 61 administrative districts since 1987. The project aims to enrich depleted Sal forests, create strip plantations along roads, highways, railways, embankments and feeder roads, create agroforestry plantations in encroached areas within Sal forests, and plantations on fallow lands outside the Water Development Board's embankments. Top priority has been given for development of village homestead groves, and augmentation of the tree cover in villages and marginal lands. This programme will increase fuelwood, fodder and food, as homestead groves mostly consist of fruit bearing trees.

The Indian government has an elaborate mechanism for dealing with the problems posed by droughts ranging from short term relief measures supply of food and water to the affected people and fodder to affected animals, employment generation for the poor etc. -- to long term measures to stabilise agricultural production in drought prone areas.

The Department of Agriculture and Cooperation is the nodal ministry for dealing with droughts. It coordinates the activities of the various ministries of the Central government and with the concerned state governments. In case of severe drought, the Central Crisis Management Group chaired by the Relief Commissioner of the Department of Agriculture meets for formulating policies and better coordination. The commissioner keeps the government informed about severe droughts. In 1987, because of the gravity of the situation, a Cabinet Committee on Drought (CCD) was formed With the Prime Minister as chairperson. Several central ministers were designated for coordinating with drought affected states. A Committee of Secretaries on Drought was set up with the cabinet secretary as the chairperson to coordinate with the concerned state governments. At the state level the State Relief Commissioner is the nodal officer who coordinates work through the state crisis management group. Sometimes cabinet committees are also formed at the state level to monitor the relief work. State ministers are sometimes given charge of various districts for monitoring relief work. At the district level, the district collector is in overall charge of drought relief work. The collector coordinates with various agencies at the district level - panchayat organisations, and offices of central institutions at the district level namely, Food Corporation of India, railways, India Meteorological Department etc.

The government makes every effort to minimise the two-fold effect of drought -- rising prices of foodgrains together with .a fall in the purchasing power of the poor -- by organising an integrated public distribution system, on one hand, and employment generation programmes, on the other. The supply of foodgrains is organised with the help of the following policies:

- Effective operation and maintenance of adequate level of buffer stocks of foodgrains;
- Expansion and strengthening of the public distribution system;
- Production and procurement;
- Stringent enforcement;
- Intensive monitoring of prices and availability situation at various levels; and,
- Export regulation and import of essential commodities.

In addition, substantial government efforts are directed towards employment generation for small and marginal farmers and landless workers. In the 1987 drought, which was one of the severest in terms of duration and extent of area, the Indian government provided a total drought assistance of Rs.1617 crore to the states, of which Rs.842 crore was earmarked for employment generation alone. This amount was spent to generate 570 million persondays of employment. The government also identified 15 major irrigation projects, 32 medium term irrigation projects and 280 minor irrigation projects in the drought affected states and sanctioned an additional Rs.118 crore to complete them in 1987- 89. In most employment generation schemes, wages are paid partly or wholly in kind. Thus, there is a direct link between employment programmes and fair price shops, which acquire crucial importance during drought years. The public distribution system (PDS) plays a significant role in providing foodgrains at lower than market prices to vulnerable groups in food deficit regions. The PDS was expanded to cover rural areas during the 1980s.

Apart from improving food supply and maintaining the incomes of the poor, the government also has to undertake supply of drinking water and feed for livestock during drought periods as part of its short term relief measures. Drought leads to a scarcity of drinking water, especially in hard rock areas. Water is then supplied through water tankers and drums. A long term solution, however, depends on improving the rural water supply system by local bodies with the active assistance of state governments. The Central Ground Water Board has conducted extensive hydro- geological surveys and established over 3500 water level monitoring stations for periodic evaluation of the behaviour of aquifers in different parts of the country.

The following steps are taken for livestock management during drought periods:
- Augmenting availability of roughage, saving fodder, and tapping of forest grasses as feed for livestock;
- Use of unconventional roughage like rice husks, wheat, husk, straw of pulses, tree leaves, sugar cane tops, bagasse etc.;
- Enrichment of roughage by adding coarse grains, oil cakes etc;
- Supply of concentrate feeds;
- Use of unconventional feed concentrates;
- Training in the use of unconventional forages/concentrates;
- Arrangements for transport and storage;
- Regulation of cattle migration;
- Provision of veterinary cover;
- Involvement of voluntary organisation; and,
- Organizational arrangement for cattle camps etc.

Long-term measures for drought management calls for investments in areas such as afforestation, soil conservation and water conservation. Broadly, these long-term measures consist of measures for stabilising agricultural productivity; efficient use of water resources; better and efficient public distribution system; improved sustenance of livestock populations; and, protection of ecological balance.

Apart from these measures, the government has also taken a number of long term measures for reducing the impact of drought. The extent of irrigation has increased from a gross irrigated area of 22.6 million ha in 1950-51 to 62.8 million ha Since 1983-84, under a centrally sponsored small and marginal farmers assistance programme, help is given for minor irrigation. The Drought Prone Area Programme is another centrally sponsored scheme, under which Rs 15 1akh is allocated to each block per year. At the end of the Sixth plan, 511 blocks of 70 districts in 13 states were covered under this programme. The Desert Development Programme, yet another central programme, was initiated in 1977-78 to cover both the hot and cold arid regions of the country. At the end of the Sixth plan, this programme covered 126 blocks in 21 districts of five states. A comprehensive crop insurance scheme was introduced in 1985, which provides financial support to farmers during natural exigencies like droughts and floods, restores the credit eligibility of farmers, and supports and stimulates production of cereals, pulses and oil seeds.

Drought management is the responsibility of both federal and provincial governments in Pakistan. The Water and Power Development Authority makes programmes for the development of water resources and power supply throughout the country, including desert and semi-desert areas, while the special purpose authorities like Baluchistan Development Authority, Arid Zone Development Authority of Sindh, Sarhad Development Authority and Thar Development Authority undertake studies and projects to enhance and upgrade the environment.

Under short term measures during drought periods, the provincial government declares drought prone areas and exempts them from land revenue; federal government provides interim relief and funds for rehabilitation and through its National Logistic Cell maintains a regular supply of food and fodder; and, employment programmes such as promotion of cottage industry and handicrafts are undertaken.

Medium term measures include the formulation and implementation of programmes by the Water and Power Development Authority for the construction of low dams and water reservoirs in water scarce areas. Provincial irrigation and power departments undertake research and execute projects to develop groundwater resources and conserve surface water. Afforestation programmes are being implemented by provincial and federal departments to conserve and extend forest areas. Urban and rural municipal bodies launch tree plantation campaigns in their areas.

As part of the government's long term measures, the Sindh Arid Zone Development Authority undertakes research to tap groundwater resources for irrigation and undertakes development projects such as expansion of agriculture, development of reservoirs and irrigation, construction of roads, provision of basic services and amenities, and formulation of long term development plans for the arid zone. The Baluchistan Development Authority undertakes similar programmes for its area. The provincial agriculture departments are implementing a programme for livestock development to raise good breeds of cattle both for milk and meat. Dairy and cattle farming have been exempted from income tax throughout the country.

Till date, Pakistan has no integrated drought management programme. Except for a few areas, there is no regional level authority to deal exclusively with arid zones of different provinces. Responsibilities are highly fragmented between a number of federal, provincial and local departments and agencies, ranging from water development, afforestation, income generation, supply of food and fodder, health and education etc.

Drought management in Sri Lanka beings with the farmers in the Dry Zone who make several presowing adjustments after watching the seasonal rains. Delay or failure of rains leads to reduced areas of cultivation. Farmers resort to short term paddy varieties in the lowlands and to drought resistant crops in the uplands. Post-sowing adjustment include stringent use of available water with priority given to crops nearing maturity and use of lift irrigation systems.

The drought relief procedure adopted by the government covers assessment of damage and distribution of rations; organising public works like desalting of irrigation channels, and construction and maintenance of roads; supply of food for work or dried rations; and, distribution of drinking water, if necessary.

The development of the Mabaweli -- the diversion of the perennial Mahaweli river into the Dry Zone to augment the irrigation systems there and to feed new areas of irrigated paddy -- is one of the long term measures to combat drought in the Dry Zone of Sri Lanka. Large new reservoirs have been created such as the Kotmale, Victoria, Randenigala and Rantambe with diversion tunnels to carry water into the dry zone areas of the eastern and northern parts of the island. The largest in the southeast is the Samanala Wewa reservoir which is nearing completion. This ambitious programme, a multipurpose settlement programme, aims to cultivate 130,000 ha of new (mostly forest) land and upgrade about 32,400 ha of single cropped land to multiple cropping. Farmers living in Sri Lanka's drought-prone areas traditionally construct tanks and supplement irrigated farming with rainfed upland farming. In the tank management system, farmers conserve rain water, clean and maintain channels, and prevent excessive flooding.

The government's master plan for forestry aims to conserve soil and water and supply wood. Its various components consist of rehabilitation of existing forest plantations; establishment of 10,000 ha of new forests each year to meet I industrial timber demand, block fuelwood plantations to meet the needs of the industry, and farmers' woodlots to produce fuelwood, poles and small timber for farmers' use and local markets; protection plantations on slopes with a gradient of over 30 and, conservation of Dry Zone protected forests.

In Sri Lanka, by 1985, the area under cultivation, known as chena land, had reached 1.6 million ha -- the second largest land resource under use. Eighty per cent of the country's foodgrains, pulses and vegetables are produced in these lands. The government has enforced a law on further clearing of forests for chena cultivation. Environmental conservation will be necessary to sustain the large reservoirs on the Mahaweli. Plans are afoot for afforestation in the Mahaweli catchment. The National Conservation Strategy has proposed the conversion of degraded tea plantations into forests or agroforests, and marginal land under agriculture to be brought under agroforestry or allowed to revert back to forests.

Strengths and Weaknesses of Drought Management in South Asia

Each country was asked to identify the strength and weakness of drought management in respective country. The feedback received has been compiled in the following matrix:

***Table 2** : Perception of Strength and Weakness of Drought Management*

Country	Strengths	Weakness
Bangladesh	1. Availability of buffer stocks of food in upazillas to meet emergencies	1. Insufficient conservation of rain water in drought affected regions. 2. Insufficient funding for water conservation 3. Inadequate public awareness 4.Inadequate afforestation programme 5. Insufficient deepest tubewells for use in emergencies 6. Fuelwood and fodder supply systems, development of drought resistant crops and the conservation of water and the attendant development of fisheries inadequate 7. Weak organizational infrastructure 8. Insufficient emergency equipment like pumps and vehicles
Bhutan	Not available	Not available
India	1. Elaborate institutional structure For drought management 2. Active research programme, using remote sensing techniques to develop early warning and monitoring systems 3. Financial support offered for projects relevant to drought mitigation 4. New technologies for multipurpose tree species, crop production, horticulture, are being developed 5. Social forestry, fuelwood and fodder programmes being undertaken on degraded forest land	1. Insufficient allocation of funds for long term measures like soil and water conservation and the development of drought resistant crops, and higher expenses on short term measures like employment generation and fuelwood and fodder supply

Country	Strengths	Weakness
Maldives	1. Collection of rainwater by roof catchments	1. Over exploitation of ground water
Nepal	1. Disaster Relief Committees 2. Improved transport and Communication network	1. Insufficient surface irrigation to tide over dry spells 2. Limited understanding of issues relating to drought 3. Stress on the construction of reservoirs and dams, to mitigate water scarcity and to generate hydroelectric power, with little assessment of the environmental impacts of these engineering solutions
Pakistan	1. Awareness of the problem at the National, provincial and local levels 2. Commendable agricultural research on the development of drought resistant species	1. Insufficient emphasis placed on afforestation 2 Weak and unintegrated institutions 3. No coordinating agency 4. Insufficient training facilities 5. Insufficient research 6. Implementation, monitoring and evaluation systems require restructuring
Sri Lanka	1. Considerable research on drought resistant and short term crop varieties 2. Research being undertaken on developed as yet innovative dryland farming, crop- livestock systems and agro-forestry 3. Surveys on the current status of shifting cultivation	1. No alternative to shifting cultivation on "chena" lands 2. Weak existing infrastructure and institutions 3. . Inadequate personnel, training and equipment.

***Source**: Regional Study on the Causes and Consequences of Natural Disasters and the Protection of and Preservation of Environment, SAARC Secretariat, Kathmandu, 1992, Reprinted by SDMC, New Delhi, 2008*

Bangladesh will have to overcome several problems to tackle the hazards of drought effectively. Firstly, more investment and efforts are necessary in the drought prone areas to conserve water. The scope of diverting riverwaters from surplus to deficit areas is limited in Bangladesh. This technology is not viable in Bangladesh because of the high order of investment needed and the loss of land that will take place. Afforestation programme are still in their infancy and greater public awareness is needed. Drought management must deal with diverse technological aspects like fuelwood and fodder supply, development of drought resistant crop varieties and conservation of water integrated with production of fish. The basic need is for appropriate planning so that immediate supply of food can be made and employment generated. Every upazila has now a buffer stock of food to meet emergencies. In most areas hand tubewells can supply drinking water, but where these tubewells fail, deep tubewells are needed.

India has an elaborate institutional structure for management of drought. It also has an active research programme to assist in drought management. The Department of Space is developing remote sensing techniques to study the vegetation status for early warning and monitoring of drought. The Department of Science and Technology and the India Meteorological Department provide financial support for projects relevant to drought mitigation and coordinate the scientific inputs needed for the national technological mission on drinking water.

The Indian Council for Agricultural Research is developing new technologies of crop production including horticulture and multipurpose tree species, suitable for rainfed and irrigated areas, with an emphasis on improved soil and water conservation practices and efficient use of available resources. The Ministry of Environment and Forests and the National Mission on Wastelands Development promote and undertake social forestry programmes, fuel and fodder development programmes on degraded forest land, and ecological research in drought affected regions.

Considering the enormity of the problem and the need for taking long term measures such as afforestation, soil and water conservation, and development of drought resistant crops, a larger allocation of financial resources is necessary. Investment on these long term measures can reduce the expenditure on short term measures such as supply of food and fodder and employment generation programmes. Resources should be allocated to treat the cause of the problem, namely, environmental degradation, rather than its various manifestations.

A major factor aggravating the natural dry spells in Nepal is the low level of surface irrigation. A maximum of 36 per cent irrigation is provided in the premonsoon season. Command area schemes meet only 30 per cent of the irrigation needs of the country. Irrigated areas in Nepal are classified as those that are able to meet 50 per cent of their total irrigation needs. On the basis of this definition, a maximum of between 50 per cent to 95 per cent of the cultivated land is unirrigated under surface flow systems. The extent of unirrigated land under groundwater programmes is considerably lower. The reliance of agricultural lands on the monsoon is, therefore, crucial. Delay in monsoons or inadequate precipitation can cause extensive drought-like conditions.

There has, however, been a limited understanding of this issue, and no attempts have been made to monitor the situation. Roods and droughts can occur in the same year and in the same location. Even less recognition is given to the fact that an apparently water surplus area can suffer from severe water scarcities when various aspects of the ecological framework are not taken into account. Ironically, the construction of reservoirs and dams in the hills, which is considered indispensable for the full utilisation of the country's water resources, has often led to the depletion of water in the surrounding micro-watersheds because of the diversion of small stream-flows to augment the reservoir. This has caused drought as a result of the withdrawal of soil moisture. Some preliminary evidence indicates considerable damage to maize crops cultivated above reservoirs due to water depletion. Furthermore, if diversion of water to augment water volumes in hydropower systems is carried out without sufficient examination of the possible effects on downstream traditional irrigation facilities, the consequences for crop production in these areas could be extremely serious. Hill farmers are particularly sensitive to water scarcity, and have autonomously developed appropriate water harvesting technologies. However, no effort has been made to assess the effect of river diversion on fragile micro-ecosystems. Engineering solutions ought to be subjected to a careful examination of their environmental impacts.

In Pakistan, the problem of drought and drylands is well recognised at national, provincial and local levels. Agricultural research organisations have done commendable work in producing species which can grow in waterlogged areas and in arid areas. Emphasis in arid areas is on drought resistant crops.

Drought Risk Reduction Framework

The United Nations International Strategy for Disaster Reduction has recommended a framework for drought risk reduction, which is closely aligned with the Hyogo Framework for Action: Building the Resilience of Nations and Communities to Disasters 2005-15. This framework is based on the following five principles:

- ***Reducing underlying factors of drought risk*** such as changing social, economic and environmental conditions, land use, weather, water, climate variability and climate change.
- ***Strengthening preparedness for drought to*** move from policies to practices in order to reduce the potential negative effects of drought.
- ***Policy and governance*** as an essential element for drought risk management and political commitment.
- ***Drought risk identification, impact assessment, and early warning***, which includes hazard monitoring and analysis, vulnerability and capability analysis, assessments of possible impacts, and the development of early warning and communication systems.
- ***Drought awareness and knowledge management*** to create the basis for a culture of drought risk reduction and resilient communities.

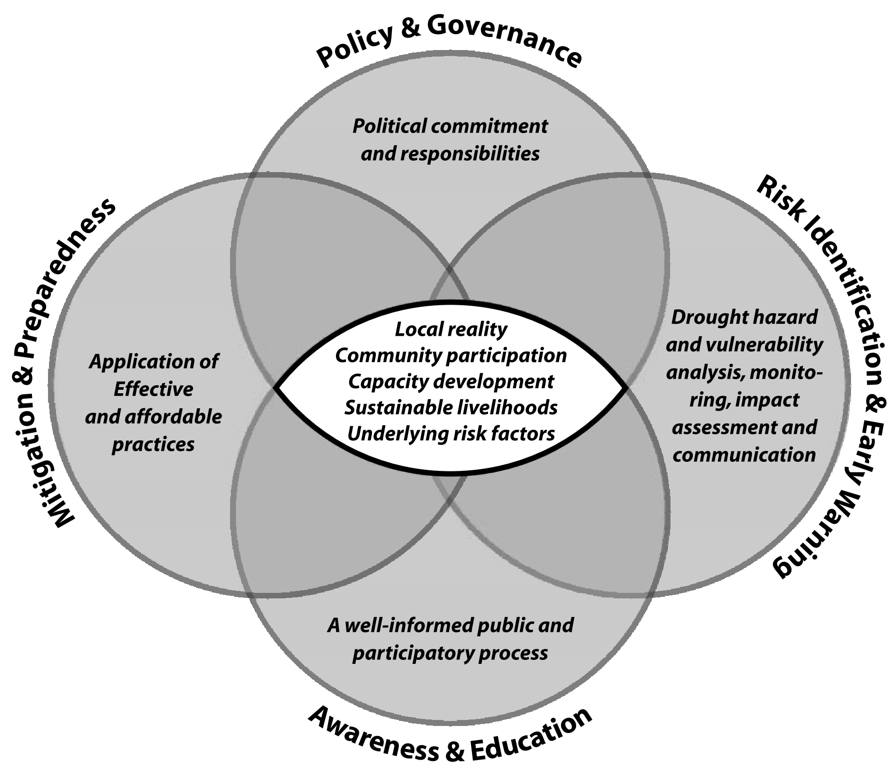

***Figure 6** : Main Elements for Drought Risk Reduction Framework*

***Source**: Drought Risk Reduction Framework and Practices: Contributing to the Implementation of the Hyogo Framework of Action, UNISDR, Geneva, 2009*

Drought Policy and Governance

Leaders and other high-level authorities at the apex of political and economic power need to be fully aware of the danger that drought poses, aware of the hardship it creates for people whose livelihoods are vulnerable to drought, and committed to disseminating information and implementing policies to help reduce human suffering and environmental degradation. A drought policy should establish a clear set of principles or operating guidelines to govern the mitigation and management of drought and its impacts as well as the development of a preparedness plan that lays out a strategy to achieve these objectives. A national policy and plan should specify the respective roles of government, local communities and land users, and the resources available and required to implement appropriate drought risk reduction activities. The Drought Mitigation Centre of the University of Nebraska-Lincoln has recommended that a sound drought policy should have the following nine components:

- Provide for effective participation at the local, national, and regional levels of non-governmental organizations and populations (both women and men) in policy planning, decision making, and implementation and review of national action programmes;
- Be rooted in thorough vulnerability, risk, capacity, and needs assessments, highlighting the root causes of the issues related to drought at national, sub-national, local, and transboundary scales;
- Focus on strengthening the capacities of governments and communities to identify, assess, and monitor drought risks at national and sub-national levels for effective development planning, including strengthening of people-centred early warning systems and preparedness;
- Incorporate both short and long-term strategies to build the resilience of governments and communities to reduce the risks associated with drought, emphasize implementation of these strategies, and ensure they are integrated with national policies for sustainable development;
- Link drought early warning indicators with appropriate drought mitigation and response actions to ensure effective drought management;
- Allow for modifications to be made in response to changing circumstances and be sufficiently flexible at the local level to cope with different socio-economic, biological and geo-physical conditions;
- Promote policies and strengthen institutional frameworks which develop cooperation and coordination, in a spirit of partnership, between the donor community, governments at all levels, local populations, and community groups, and facilitate access by local populations to appropriate information and technology;
- Designate agencies and stakeholders responsible for carrying out drought mitigation and response actions, and require regular review of, and progress reports on, their implementation.
- Strengthen drought preparedness and management, including drought contingency plans at the local, national, sub-regional and regional levels that take into consideration seasonal to inter-annual climate predictions.

Much more is the implementation of policy which depends on the system of governance prevailing in the country. Many countries have been failing on this account as much of the professed policies are actually not practiced on the ground.

Drought Risk Identification and Early Warning

Understanding the physical nature of the drought hazard and the corresponding impacts and underlying vulnerabilities, and communicating these dangers in an effective manner, forms the basis for developing informed drought mitigation and preparedness measures to reduce the effect of impact of drought while contributing to drought-resilient societies. Drought risk identification, impact assessment, and early warning activities should be guided by the following principles:

- Drought risk is the combination of the natural hazard and the human, social, economic and environmental vulnerability of a community or country, and managing risk requires understanding these two components and related factors in space and time.
- Increasing individual, community, institutional and national capacities is essential to reducing vulnerability to drought impact.
- Impact assessment plays an important role in drought risk management, in particular, identifying most vulnerable groups and sectors during drought.
- Drought monitoring and early warning systems play an important role in risk identification, assessment and management.
- Changing climate and the associated changing nature of drought poses a serious risk to the environment, hence to sustainable development and the society.
- Drought is typically a slow-onset phenomenon, which means that it is often possible to provide early warning of an emerging drought. Such information allows for a shift from reactive to proactive hazard management and represents a change in focus from disaster recovery to disaster prevention.
- Because there is no single definition for drought, its onset and termination are difficult to determine. We can, however, identify various indicators of drought specific to sectors or water uses, and tracking these indicators provides us with a crucial means of monitoring and providing early drought warnings.
- A global survey conducted by the UNISDR Platform for the Promotion of Early Warning concluded that early warning systems for drought are more complex than those for other hydro-meteorological hazards and are, consequently, relatively less developed globally. They are heavily reliant on monitoring observed patterns of monthly and seasonal rainfall, streamflow, groundwater levels, snowpack and other parameters and the use of historical and statistical data. The study also stressed the importance of "people-centred" early warning systems, i.e., systems that are focused on reaching the people affected and providing them with meaningful information that they can act on.
- Recent advances in satellite based medium range weather monitoring system in India and other countries have made it possible to provide accurate rainfall prediction to the farmers on a weekly and monthly basis on the basis of which advisories can be sent to the farmers regarding use of appropriate seeds, cropping pattern etc.

Crop Weather Watch Group, Ministry of Agriculture, Government of India

In India, the Crop Weather Watch Group within the Union Ministry of Agriculture evaluates information and data furnished by Indian and other agencies to determine the likely effects of meteorological and other environmental parameters on agriculture. The group meets every Monday during the rainy season (June to September) and the frequency of meetings increases during drought events. The group is derived of representatives from several different sectors, and utilizes several different communication nodes to relay drought monitoring information from the field to decision makers.

Composition of CWWG

Partners	Tasks
Additional Secretary, Ministry of Agriculture	Chairperson of the Group; promotes overall coordination
Economic & Statistical Adviser, MOA	Report behavior of agro-climatic and market indicators
India Meteorological Department	Rainfall forecast and progress of monsoonal conditions
Central Water Commission	Water-availability monitoring in major reservoirs
Plant Protection Division	Watch pests and diseases outbreak
Crop Specialists	Crop conditions and production
Agricultural input supply divisions	Supply and demand of agricultural inputs
Agricultural extension specialists	Report on field-level farm operations
Ministry of Power	Manage electrical power for groundwater extraction
Indian Council of Agricultural Research	Technical input and contingency planning
National Center for Medium Range Research	Provide medium-term forecasts

Details of CWWG Monitoring and Information Management

Parameters	National agencies	State agencies	District agencies	Field agencies	Communication mode
A. Meteorological					
Delay in the onset of monsoon	W	W	D	D	Wireless/Fax/Telephone/e-mail
Dry spell during sowing	W	W	D	D	Wireless/Fax/Telephone/e-mail
Dry spells during critical					
crop-growth periods	w	w	D	D	Wireless/Fax/Telephone/e-mail
B. Hydrological					
Water availability in Reservoirs	w	w	D	D	Wireless/Fax/Telephone/ e-mail/ Written report
Water availability in tanks/ lakes	F	F	F	W	Written reports
Stream flow	F	F	F	W	Written reports
Groundwater level	S	S	S	S	Written reports
Soil moisture deficit	F	F	F	F	Written reports
C. Agricultural					
Delay in sowing	W	W	W	W	Wireless/Fax/Telephone/e-mail
Sown area	W	W	W	W	Wireless/Fax/Telephone/e-mail
Crop vigor	F	F	F	W	Written reports
Change in cropping pattern	W	w	W	W	Wireless/Fax/Telephone/e-mail
Supply and demand of agricultural inputs	W	w	W	W	Wireless/Fax/Telephone/ NICNET

D = Daily; W= Weekly; F= Fortnightly; M= Monthly; S = Seasonal (Pre- and Post-rains)
***Source**: J.S. Samra, 2004, Review and Analysis of Drought Monitoring, Declaration, and Management in India, Working Paper 84, International* Water Management Institute

Drought Awareness and Knowledge Management

Today, the world has a wealth of knowledge and information on disaster risk reduction at its disposal; the key is compiling, collecting, sharing, and using this in a proactive way through awareness-raising and educational initiatives so that people can make informed decisions and take action to best protect themselves and their property and livelihoods from natural hazards. In general, drought awareness and knowledge management activities should be guided by the following principles:

- The effects of drought can be substantially reduced if people are well informed and motivated toward a culture of disaster prevention and resilience,
- Effective information management and exchange requires strengthening dialogue and networks among disaster researchers, practitioners, and stakeholders in order to foster consistent knowledge collection and meaningful message dissemination,
- Public awareness programmes should be designed and implemented with a clear understanding of local perspectives and needs, and promote engagement of the media to stimulate a culture of disaster resilience, including resilience to drought and strong community involvement,
- Education and training are essential for all people in order to reduce local drought risk.

The national and provincial governments and scientific, technical, academic and research institutions working on various aspects of drought risk management have primary responsibilities for dissemination of drought awareness among all relevant stakeholders within the respective countries. In the regional context, knowledge and information sharing on drought risk management among the countries and communities has been virtually non-existent. This is one area where new initiative can be taken without much investment but with immense benefits to all concerned.

Reducing Underlying Factors of Drought Risks

Reducing drought vulnerability requires reducing underlying risk factors by effective environmental and natural resource management, social and economic development practices, and land-use planning and other technical measures. These factors that have an impact on vulnerability to drought need to be reflected in national poverty reduction strategies, development plans, sector development planning and programmes, and environment and natural resource management strategies as well as in post-disaster situations so that effective preparedness and mitigation measures can be considered.

The guiding principles for reducing the underlying factors of drought risks may be enumerated as under:

- Mechanisms should be in place to systematic call bring together practitioners in disaster risk reduction (e.g., national platform members) and key institutions involved in environmental management (e.g., adaptation to climate change, desertification and biodiversity).
- Areas of overlap and synergy should be identified between existing environmental programmes and disaster risk reduction activities.
- A mechanism for carrying out joint assessments should be institutionalized to integrate disaster risk reduction and environmental protection parameters (e.g., integrated risk-and-environmental-impact assessments).
- Specific attention should be given to socio-economic high-risk factors such as age, disabilities, social disparities and gender. By focusing on protection of the most vulnerable groups, the impacts of disasters can be reduced.

- Post-drought recovery planning can incorporate drought risk reduction strategies for the future.
- Safety nets such as insurance mechanisms for properties as well as microcredit and financing for ensuring minimum livelihood means can accelerate post-drought recovery process

Drought Mitigation and Preparedness

The goal of drought mitigation and preparedness is to reduce drought vulnerability and foster drought-resilient societies."Mitigation" is defined as "the lessening or limitation of the adverse impacts of hazards and related disasters". "Preparedness" is defined as "the knowledge and capacities developed by governments, professional response and recovery organizations, communities and individuals to effectively anticipate, respond to, and recover from, the impacts of likely, imminent or current hazard events or conditions".

Before the onset of drought, mitigation actions can be implemented to build resilience into an enterprise or system so that it will be less affected when drought eventually occurs. Some mitigation actions can require relatively small changes in our lives while others may require the re-evaluation and modification of more basic elements of our livelihoods and production systems. An important mitigation measure is the development of drought preparedness and contingency plans that detail specific measures to be taken by individuals or responsible agencies both before and during drought.

Drought impacts and losses can be substantially reduced if authorities, individuals, and communities are well-prepared, ready to act, and equipped with the knowledge and capacities for effective drought management. It should be recognized that mitigation and preparedness have a greater impact on reducing the scale and effects of drought disasters than ad-hoc emergency response measures.

The guiding principles of drought mitigation and preparedness have been enumerated as under:

- Prevention, mitigation and preparedness are central components of disaster risk reduction, and are more important than relying solely on ad-hoc emergency response measures.
- Dialogue, exchange of information, and coordination are needed between disaster risk reduction, development and emergency management actors.
- The selection of appropriate drought risk reduction (prevention, mitigation and preparedness) measures requires many considerations, such as integrated environmental and natural resource management, social and economic development, land use planning opportunities, and climate change adaptations.
- A combination of top-down and bottom-up approaches is required for development and implementation of effective mitigation and preparedness measures.
- Institutional capacity, coordinated mechanisms, identification of local needs and indigenous knowledge are required to implement effective mitigation and preparedness strategies.
- Monitoring and early warning are key elements of disaster risk reduction and must be closely linked to other risk reduction actions.
- Drought risk reduction (prevention, mitigation and preparedness) requires a long-term commitment of resources.

Effective drought risk management requires a combination of measures, related with prevention, mitigation and preparedness for response. Drought response or relief measures often result in immediate effects on people's lives and livelihoods. For example, direct food and cash distribution saves lives and benefits livelihoods in the short term. However, these efforts can also create dependency and other new vulnerabilities and may not reduce underlying drought risk factors and vulnerabilities. Therefore, the same affected individuals may experience similar or more extreme conditions the next time a drought occurs. Although drought relief is an important safety net and is often politically appealing, it should not be the primary focus in drought risk reduction.

The selection of risk management options must be evaluated in the context of constraints and issues. Some constraints could include time, financial and personnel resources, geography, feasibility, the level and nature of development and vulnerability, the attitudes and desires of the affected communities and landowners, legalities, public acceptance, and liability. They must also take into account social factors such as gender, age, and other social and economic capacities. Women, children, the elderly, the poor and the disable are especially vulnerable to the effects of drought. Special consideration must be given to these populations and to those livelihoods least able to cope with drought.

Risk reduction measures should complement those of other programmes focusing on public health, economic development, education, environmental management, and adaptation to climate change. For example, when appropriate, integrating drought risk reduction planning into the health sector can pay long-term dividends. In this regard, planners can promote activities that assist the health sector in monitoring the health impacts of drought and develop their capacity to help prevent, mitigate and prepare for drought negative impacts. This includes fostering food security and livelihood diversification to ensure the resilience of communities to drought and other hazards that can weaken agriculture-based livelihoods.

In regard to economic development, planners should promote diversified income options for populations in high-risk areas to reduce their vulnerability to drought, and ensure that their income and assets are not undermined by development processes that increase their vulnerability. These efforts should parallel those that promote the development of innovative financial instruments and risk-sharing mechanisms, particularly insurance against drought. For example, the innovative market-based solutions such as index-based weather insurance and price risk insurance linked to credit have been found to be very effective I some situations. A combination of resilience-building actions and safety nets for exceptional circumstances provides a balanced approach to drought risk reduction.

In recent years, sustainability has also been increasingly stressed as essential for creating more resilient systems and reducing the effects of natural hazards. Therefore, planners should encourage the sustainable use and management of ecosystems, including better land-use planning and development activities to reduce drought risk. This includes mainstreaming drought risk considerations into planning procedures for major development projects such as the creation of settlements, urban growth projects, and building and water supply regulations and management.

Overall, drought risk reduction strategies must be realistic, as well as socially and environmentally compatible. This means that the specific activities in the drought risk reduction strategies must take place on a scale that is meaningful to those who must act, whether at the national, regional, or local level.

Regional Cooperation for Drought Risk Management

Historically disaster management in South Asia started with drought management. Successive droughts and the resultant famines which killed people in millions gave rise to the concept of administration and management of relief. Till recently, in major countries like India, disaster management remained the subject of Ministry of Agriculture primarily because drought and failure of crop was the main focus of managing disasters. The colonial government had developed the Famine Codes which largely influenced the relief manuals of the different state governments post independence, with focus on payment of ex-gratia relief, distribution of food, fodder and organisation of relief works to supplement the income of the farmers and agricultural labourers. Although the impact of drought on the economy has reduced to a large extent due to diversification of economy and large scale improvement of irrigation and agricultural system, periodic drought still remains the most creeping and devastating disaster of South Asia. The climate change and its impact on water scarcity in the region are projected to worsen the drought situation of the region in the long run.

Almost every country of South Asia has decades of experience of dealing with droughts. Most of these experiences have not been documented and have almost gone into oblivion. What is even more unfortunate is that each country has so far worked in isolation in their difficult and challenging tasks of managing droughts. They have not been much motivated to look beyond to find out what their neighbours have been doing and whether there are good practices that are worthy of emulation. Even the scientists and researchers from the disciplines of meteorology, agriculture, soil, hydrology etc never took the initiative of developing a network on drought in the region, whereas such networks have been in existence in many regions including Africa. Surely time has come to break this logjam and establish channels and networks of communication among scientists, policy makers and practitioners in the countries of the region to interact and share knowledge and good practices, develop regional early warning systems of drought, organize trainings and workshops and establish joint regional projects of drought mitigation and preparedness that will be of mutual benefit to the countries and communities of the region.

The SAARC Workshop on Drought Risk Mitigation and Management organised by the SAARC Disaster Management Centre New Delhi, in collaboration with the Afghanistan National Disaster Management Authority in Kabul on 8-9 August 2010 is the first ever attempt to hold a regional consultation on drought risk management in South Asia. The workshop has the challenging task of developing the blue print of a commonly agreed road map for regional cooperation on drought risk management on the basis of which projects on regional cooperation for a short, medium and long term period shall be prepared.

Surely this would be a historic opportunity to understand the challenges and perspectives of each country, assess the mutual strength and weaknesses and develop a framework for working together to address the problems and issues of regional nature for the benefit of the people of the region.

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Drought Impacts and Potential for their Mitigation in Southern and Western Afghanistan

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Introduction

The western parts of south Asia, comprising parts of west India, Pakistan, Afghanistan and Iran constitute, perhaps, the largest contiguous geographical area in the world affected by droughts. The situation needs special attention because of the high frequency of drought occurrence, high population density and poor economic conditions of the population in this region. Governments and other stakeholders in the region need to be informed on the causes of droughts and their pos¬sible mitigation measures in order to alleviate human sufferings. In 2003, the International Water Management Institute (IWMI) initiated a regional study on drought assessment and mitigation in southwest Asia, including individual studies in west India, Pakistan and Afghanistan. Catholic Relief Services (CRS) conducted a quick situation analysis of drought mitigation in the country, focusing primarily on southern and western provinces. The study was conducted in cooperation with the Faculty of Agriculture of Kabul University, Ministry for Irrigation, Water Resources and Environ¬ment (MIWRE) and FAO-Afghanistan. The purpose of this component was threefold:

- To survey farmers' attitude and level of knowledge for coping with the drought.
- To asses the current level of response from government and other agencies.
- To suggest possible approaches/measures for drought mitigation in the future.

Study Areas

Many parts of Afghanistan with the exception of northeastern highlands are facing frequent droughts. This survey focused on the southern and western provinces for the following reasons:

- Southern part of Afghanistan is receiving the least rainfall (100-300 mm per year) followed by western (20CM-00 mm) and northern parts.
- Shallow soils and bare rocks in all these regions do not retain moisture.
- Lack of vegetative cover and the high population density in the region make this area highly vulnerable to droughts.
- Strong winds from April to August have a severe desiccative effect.
- Food insecurity levels are very high in these parts of the country.

According to Asian Development Bank (ADB), localized droughts in different parts of the country have a return period of 3 to 5 years. Droughts, covering large areas recur every 9-11 years, while droughts of a nation-wide extent have a return period of about 20-30 years (ADB cited in WFP 2003). According to the ADB report, the latest (and still current) drought is unusual because of the combined effect of its duration and wide geographical extent. This combination has made this drought especially destructive to the natural resource base and subsequently to the livelihoods of millions of people residing in the drought areas.

The South

The southern provinces of Nimroz, Kandahar, Uruzgan and Zabul (figure 1) extend from the foot¬hills of the central and southern mountains into open plains dominated by rocky outcrops and desert sands. Four main rivers originating in the mountains to the north and east—the Khash, the Helmand, the Arghandab and the Arghistan—flow though the area around which most agricultural activities take place. Along these water-courses and in the urban centers, population density is high. The rest of the area is relatively uninhabited due to the hostile natural environment, though small settle¬ments can be found around desert oases and karezes (covered springs). In recent times, the south has experienced heavy fighting and conflict, with much infrastructure—including irrigation sys¬tems—being neglected or destroyed.

Low altitude rain-fed lands are found in parts of Helmand, Kandahar, Uruzgan and Zabul provinces though most agriculture is conducted in fields irrigated through canal systems along the river courses. More than half of the agricultural systems in Uruzgan (estimated at 60% of agricultural activity) rely on karezes and intermittent flood irrigation, closely followed by Zabul (estimated at 40%), Kandahar (estimated at 20%) and Helmand (estimated at 15% [WFP 2003]). The main crops are wheat and, to a lesser extent, barley. There are two agricultural seasons: the first cultivation takes place from November to December, and the second from June to July. Secondary crops include maize, cotton, beans, pulses, melons, cumin and poppy. Vineyards, pomegranate and almond orchards are also found in the area.

The West

The western areas of the country extend south from the rolling hills and pistachio forests of north¬ern Badghis to the Hirat province, from the rocky arid lands of western Hirat and Farah provinces eastward to steep mountain regions of Ghor and southern Badghis. People are concentrated in the provincial cities and urban centers scattered throughout the provinces. The city of Hirat, one of the outposts along the ancient silk route of the east, is the main urban hub of the area. In compari¬son to other parts of Afghanistan, the rural areas are not overly populated, with villages concen¬trated westwards from the mountains. Three main rivers—the Murghab, Harirud and Farahrud— flow through the area where irrigated agriculture and horticulture take place along their banks.

In the arid lands of central and southern Hirat and Farah provinces, farming relies on karez irrigation—estimated at 40% and 90%, respectively, while in the mountainous areas agriculture centers around rain-fed (approximately 65%) and mountain spring irrigated lands (estimated at 35%) with wheat being the predominant crop. In eastern Badghis and into western Hirat, there is an extensive belt of primarily rain-fed land on which most agricultural activity takes place, estimated at 90% and 60%, respectively, for the two provinces. A few large landowners, with whom most of the rural population share the crop or for whom they work, are found in the area. However, the majority of rural families are small landholders. The main crop is wheat, with secondary production of barley, peas, corn and cumin. In normal years, many farmers cultivated a second crop of rice, corn and lentils, though this has decreased due to water shortages, with the exception of the irrigated lands along the Murghab river in the Badghis province. In some districts of Hirat and Farah provinces vineyards and orchards consisting of peach, apricot, plum and walnut trees are watered from the rivers. Fruits and vegetables—melons, eggplants, tomatoes and okra—are also grown in the area.

Data and Methods

Survey of Farmers' Perception on Drought-Related Issues

Over the past 25 years, not much research or interventions has occurred in Afghanistan due to persistent war and government instability. Therefore, field data collection was the primary activity of this study. Unfortunately, deteriorating security in the study areas (both south and west) pre¬cluded the research team from visiting many sites.

The survey focused on Ghor and Badghis provinces (figure 1), severely affected by the recent drought and, at the same time, the least accessible due to lack of roads and security reasons. Therefore, special emphasis was given to collect data from these two areas. A bilingual (Dari and English) questionnaire was developed and pretested. Students from Ghor and Badghis provinces were identified in the Agriculture Faculty of the Kabul University. These students were trained in the data collection procedure before being sent to the field. At the provincial headquarters, through interactions with government officials, most drought-affected districts were identified. Further, at the district headquarters, government officials located severely affected villages, some of which were so difficult to reach that the interviewers had to use donkeys as transport. Data were collected from five villages in each of the provinces and from each village five farmers were interviewed. In some places women schoolteachers were contacted as well.

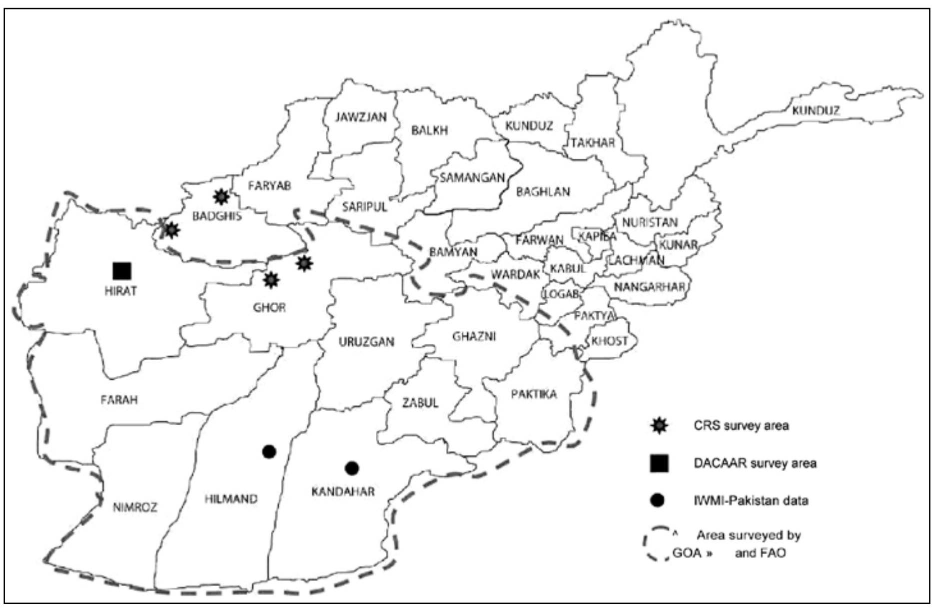

Figure 1: *Provinces and locations surveyed by different organizations*

A comprehensive study was conducted by MIWRE in several other provinces including Khost, Paktia, Paktika, Ghazni, Zabul, Uruzgan, Ghor, Kandahar, Farah, Helmand, Nimroz and Hirat. The study was conducted from 13 May to 15 June of 2004 and the results are summarized in the report on "Emergency Drought Assessment in 12 Vulnerable Southern Provinces" prepared by MIWRE (Anonymous 2004). FAO, in consultation with MIWRE, WFP and several Ministries (Internal Affairs, Agriculture and Animal Husbandry, Rural Rehabilitation and Development, Urban Development and Housing and Mine and Industry) prepared a questionnaire that was used for information collection. The mission that collected the information was a multidisciplinary team which included high-level government officials, intellectuals, people's representatives, councils, deputies and elders. The members of the multidisciplinary drought study team visited water-storage dams, water-prevention structures, rivers, canals, springs, karezes, provinces, districts and villages. The mission also visited shallow wells, deep wells, arable lands, gardens, vineyards and cattle herds. It reviewed living and dwelling conditions of people, refugees' repatriation, recent immigrations, security and health conditions.

Additional data on rural vulnerability and food-needs assessment in Nimroz, Kandahar, Urozgan, Zabul, Badghis, Ghor, Hirat and Farah provinces were available from WFP (WFP 2003). Danish Agency for Coordination of Assistance to Afghan Refugees (DACAAR) supplied drought-related information from the Pastun Zargon district in the Hirat province. IWMI-Pakistan conducted a separate survey of households and communities in the Helmand and Khandagar provinces (Qureshi and Akhtar 2004).

Survey of Government Officials

In addition to field surveys of the drought-affected population and review of the relevant supporting reports produced by other organizations listed above, the study set to interview some government officials who deal with different aspects of droughts due to the nature of their responsibilities. A bi¬lingual (English and Dari) questionnaire was prepared for interviewing different government officials for capturing their thoughts and ideas in drought-related issues. Prof. Mohsini, Dean of the Faculty of Agriculture at Kabul University and one of the coauthors of this paper, conducted the survey.

Rainfall Data

Although rainfall analysis itself was not part of this study, the collection of rainfall data (for par¬allel studies) was. More specifically, the study attempted to collect long-term monthly time series on rainfall. Such data are required for accurate quantification of drought occurrence and severity in different parts of the country. The availability of long-term records in Afghanistan, however, is extremely limited. Over the last 20 years, very limited data collection activities were conducted, while many historical data from previous years were lost. Other historical records are scattered in different reports, in different institutions and are difficult to access. It is commonly unclear where the data may be available and the data "collection" is effectively the process of trial and error. Different organizations were approached in the search for rainfall data, including national Minis¬tries (e.g., Ministry of Agriculture, Ministry of Aviation, etc.). During this process, the rainfall time series were collected for 17 locations in the country. Only 5 rainfall stations (primarily lo¬cated at the airports) have rainfall records for 20 years and longer. Others have data only for 4 to 13 years. None of the stations cover the period after 1992. Recently, FAO started to consolidate historical rainfall data along with the analysis of current rainfall. FAO has data on long-term av¬erage rainfall for 77 rainfall stations throughout the country. However, to date, the authors have not been able to find the monthly rainfall time series for these stations.

Impacts of Drought

The impacts of current and future droughts in Afghanistan have to be evaluated not only in the context of the country's history of war and unrest but also in the context of the general agricul¬tural statistics. The detailed pooled provincial land cover statistics gives the following information (table 1).

***Table 1**: Land cover of Afghanistan (Anonymous 1999).*

Land cover	Area (ha)	Area of the country (%)
Urban	29,494	0.05
Orchards	94,217	0.1
Agricultural land irrigated	3,207,790	5
Intensive	1,559,654	2.4
Intermittent	1,648,136	2.6
Agricultural land rain-fed	4,517,714	7
Forests	1,337582	2.1
Rangelands	29,176,732	45.2
Barren land	24,067,016	37.3
Marshland	417,563	0.6
Water bodies	248,187	0.4
Snow-covered areas	1,463,101	2.3
Total	**64,559,396**	**100**

The area covered by agricultural land is 12% of Afghanistan's land area, which amounts to 7,725,504 hectares. Of the total agricultural land, 5% is under irrigation (both intensive and intermittent) and 7% under rain-fed agriculture (table 1). Importantly, over 45% of the total land is rangelands (table 1). It is clear from these data that the contribution from animal husbandry to livelihoods in Afghanistan is substantial although it naturally differs between provinces (Grace and Pain 2004).

Livelihoods and Impacts of Drought in the South

Livelihoods

The results of the surveys suggest that the main livelihoods for Afghans in the south are based on agricultural and livestock production. Labor opportunities revolve around agricultural seasons, where work can be found in the fields of larger landowners—owning medium to large-sized agricultural plots that range from 10 to 300 jeribs (1 jerib = 2,000 m2 of land). Some additional labor oppor¬tunities exist in the urban centers and the frontier trading towns of Zaranj, on the Iranian border and Spin Boldak, on the Pakistani border. The majority of the people, however, are sharecroppers and small landowners, with plots typically ranging from one to ten jeribs. Animal husbandry also plays a significant role in people's livelihoods, where they own herds of camels, cattle, sheep and goats. Additional household income is derived from handicrafts made by women for trade in the local area with some export to Pakistan.

Limited Irrigation Water

Lack of snowfall during the winter and less-than-normal rain have decreased water availability for irrigation in the south, especially in summer. Generally, the only irrigated areas are upstream-irri¬gated fields at the base of the mountains and canal irrigated fields along the banks of Helmand river, as far south as the town of Garmseer. All other rivers and watercourses are almost, if not completely, dry. Underground water tables have fallen significantly negatively impacting agricul¬tural producers who rely on springs and karezes. Villagers have estimated that the water levels in their wells have dropped by as much as 5 to 10 meters compared to the situation in 2001. These survey results are supported by similar findings from FAO (annex 1), which shows that during the latest drought, in most of the provinces of the south and west, there was a marked reduction in the number of shallow wells, deep wells, karezes and hand pumps.

Reduction of Crop Yields

With the exception of the upstream canal irrigated districts of Helmand province, where surpluses have been recorded, wheat losses in other irrigated areas have been severe. Downstream canal and karez irrigated farmlands in both highland and lowland areas have been acutely affected as a result of the decrease in water sources. Many fruit trees and vineyards have died. Yield reductions of up to 75-100% of the normal harvest have been recorded in these areas. Rain-fed agriculture has failed, and a vast expanse of dusty, dry farmlands dominates the countryside. Due to this lack of water, many farmers did not plant second crops in most areas outside of Helmand province.

Potable Water

Safe potable water is a serious concern, as many wells have dried up completely. Communities keep deepening their wells, but wells continue to run dry and people are becoming too impover¬ished to afford the digging of deeper wells. Deepening a well can cost, on average, about 35,000 Afghanis, while a government employee brings home a salary of 2,000 Afghanis a month (Kabul Weekly, August 25, 2004). In the Zaranj district of Nimroz province, people are forced to buy water for 2 to 3 Afghans per liter from suppliers.

Coping Strategies

The traditional coping mechanisms for people in the south are close to exhaustion. They have sold belongings—agricultural lands, livestock, and household assets—taken loans and mortgaged their lands. This is particularly true for families living in the spring, karez and downstream irrigated agricultural areas. Farmers have reported that the prices of these irrigated lands have dropped by more than 50% compared to those in normal years, and they are now battling with the double-edged sword of desperately trying to sell their lands at a time of reduced prices. Labor opportuni¬ties are now almost entirely limited to the main provincial cities as a result of agricultural failure and restrictions across the borders.

Livelihoods and Impacts of Drought in the West

Livelihoods

Livelihoods for people living in the west, with the exception of Badghis and Ghor provinces, are relatively more diverse than in other regions of the country. In addition to agriculture, livestock own¬ership plays a large role in people's livelihoods—cattle, donkeys, and camels are owned, and large herds of sheep and goats are used for dairy production, sale, trade and transport. Wool and hides from the Badghis province are sold within the country and these are major exports to Pakistan. Work opportunities are based on agricultural activities with seasonal migration to Iran for work.

Currently, the main sources of income for many people in the west are seasonal agricultural labor, sale of livestock and other household assets, sale of agricultural production, remittances from family members working in Iran, loans and mortgaging of land. It has been estimated that 20% to 30% of the population work within the districts during the cultivation and harvesting seasons, or as sharecroppers and shepherds. An estimated 30% to 40% of male laborers seasonally migrate to the urban centers of Hirat and Farah, while up to 40% to 50% cross the border into Iran in the hope of finding work and sending back remittances to their families.

Livestock

Livestock numbers have been greatly reduced over the last few years due to continuous drought, while animal birth rates have also gone down due to poor-quality pasturelands.

Lack of Access to Safe Drinking Water

In many areas, people are facing shortages of safe potable water due to the decrease of water in the underground aquifers. In the Sange Atash district of Badghis province, drinking water is salty and unpalatable, forcing people to spend their meager incomes on purchasing drinking water.

In some provinces, springs and karezes are 90% dry. In many shallow wells, the water levels have dropped up to 12 meters. In some areas, especially in Nimroz, salty water has percolated into the wells. Many shallow wells up to 30 meters in depth are dry. In some parts of Khost, people have to travel up to 12 km to collect drinking water from the closest usable source. In urban areas, the old water supply systems cannot cope with the expanded city limits and water supply networks. In Ghor and Paktia provinces, there are no city water-supply networks.

In many villages, especially in Ghor and Badghis, there were traditional systems of collecting cha (winter snow) in underground storage tanks (figure 2). Cha can be as deep as 20 meters. They used to be not only sufficient for the needs of the families but also provided enough water to sell to other families during summer. It appears from the survey results that the government and NGOs are, however, not promoting this traditional snow-/water-harvesting technology.

Figure 2 : *Cha (harvesting snow in wells) in Ghor*

Irrigation and Cultivation

Due to the current drought, irrigation potential of the existing water bodies and storage dams has been greatly reduced. In Kandahar province, the main gates in the Dahla dam have been recon¬structed but, due to increased sedimentation, the capacity of the reservoir has decreased. In the villages of Ghor, Badghis and Hirat, where surveys were done, irrigated cultivation has decreased by 15-70%. Operational and semi-operational karezes, especially in Uruzgan, Helmand, Gazni and Hirat need urgent cleaning and improvement.

Reduction in Crop Diversity and Yield

Most farmers interviewed said that the area under cultivation had decreased while crop diversity had also reduced substantially. Many farmers in Ghor, Hirat and Badghis reported that in normal years they were cultivating seven different types of crops: wheat, barley, peas, mung bean, clover, cotton and melon. But due to the drought they are cultivating only wheat and peas and, in some cases, barley. Farmers interviewed in these three villages indicated a yield reduction of about 17-88%. Peas and cotton recorded the highest (88%) and the lowest (17%) yield reductions, respec¬tively. In cereals like wheat and barley the reductions were around 50-70%.

Expansion of Illicit Crops

In some provinces, like Helmand, Kandahar, Zabul, Urozgan and Ghor, an increasing number of landlords vare engaged in poppy cultivation. Because of low levels of production of agriculture crops due to the drought, even the expenditure on seeds and fertilizers cannot be compensated for by the expected harvests. In the Guzara district of Hirat, sporadic cultivation of smoking cannabis is also observed mainly for the same reasons.

Forests, Pastures and Animal Stocks

Forests and pastures in the drought-affected areas have been decreased by around 80% in Nimroz, Helmand and Farah provinces. Communal grazing lands have been eliminated in many parts of the country, especially in the western and southern parts due to drought and the movement of sand dunes. Even when the communal grazing land exists, its productivity and carrying capacity have been greatly reduced. When asked about the current levels of productivity of pasturelands as com¬pared to normal and average rainfall years, the farmers in Ghor and Badghis indicated that the level is below 50%. In Ghor, Badghis and Herat provinces the animal population has decreased significantly. While the number of cows has decreased by 20-50% the number of goats and sheep has decreased by 40-65%. Farmers stated that birth rates of animals have also gone down. The degradation of the pasturelands has resulted in a significant decrease in the available forage for the livestock of the kuchi (pastoral nomads) (figure 3) and the number of their animals has de¬creased significantly as compared to the number in normal rainfall years. The selling price of ani¬mals has gone down by 15-30% as compared to the number in non-drought years.

***Figure 3** : A settlement of the kuchi (nomadic shepherds).*

Migration and Joblessness

Economic difficulties in the rural areas leading to joblessness have increased poverty levels. In most rural areas, particularly in Ghor, Nimroz, Paktia, Gazni and the upper part of Helmand prov¬inces, many villagers have migrated to provincial centers because of the lack of both water and employment opportunities. Many families, and in particular the young and able-bodied persons, have migrated to cities, the capital (Kabul), and further to Iran and Pakistan.

Impacts on Children

One effect of the above migration on young people is the high rate of child labor in various prov¬inces. Also, at least 5% to 7% farmers who were interviewed in Ghor and Badghis provinces ad¬mitted that due to drought they arranged and received money for early marriage of their daughters.

Tables 2 *: summarize the impacts of the recent drought on different aspects of life in the sur¬veyed provinces.*

Province	Decline in 2004 (drought year) to 2003 (normal year)						Social effects
	Crop diversity (%)	Area cultivated (%)	Yield (%)	Area irrigated (%)	Water table (m)	Number of animals (%)	
Badghis	30-60	15-70	20-78	50-75	3-4	20-60	M, EM,CL, IC
Ghor	40-65	20-60	25-75	50-75	2-4	25-55	M, EM,CL,IC
Hirat	25-70	21- 67	17-88	51-86	2-4	20-50	M, IC

Note: *M = Migration; EM = Early marriage of daughters; CL = Child labor; IC = Illegal crops.*

Table 3 *: Summary of impacts and coping methods*

Effects/symptoms of drought	Coping strategies adopted
Shortage of potable water and groundwater	• Unplanned digging of wells
Shortage of irrigation water for cultivation	• Increasing joblessness and selling of assets
Shrinkage of rain-fed agriculture	• A rise in the cultivation of poppy and other illegal crops
Reduction in animal husbandry	• Migration and related social problems
Diminished forests	• Child labor
Diminished quality of rangeland	• Early marriage of girls in exchange for money
Loss of crop diversity and productivity	

Possible Measures for Future Drought Management

Current Activities and Perceived Needs

Drought impact management implies both short-term measures and long-term planning. Interviews with villagers and government officials helped identify some current activities and future anti-drought needs and strategies.

The Government of Afghanistan has undertaken certain steps for drought mitigation. A Dari/ English bilingual monthly bulletin on food security is now being published by the Ministry of Agriculture with the support of the FAO—to inform a wider audience of meteorological conditions in different parts of country and potential impacts on agriculture.

In the Ministry of Internal Affairs, a special division has been organized to respond to emergency situations. It is not clear, however, whether drought "falls" under this department. Currently, MIWRE examines possibilities to improve drought monitoring in collaboration with other ministries such as the Ministry of Agriculture and Animal Husbandry and the Ministry of Rural Development and Reconstruction.

In addition to the already mentioned emergency drought assessment in 12 southern provinces, MIWRE has initiated a similar survey in 14 provinces (central and northern) of the country. The purpose of these surveys is to understand the realities on the ground and to identify which priorities should be presented to international donors for emergency drought relief and mitigation.

Many interviewed persons of authority felt that establishing a Drought Commission at the national level as well as its regional suboffices may help alleviate the impacts of future droughts.

Also, many felt that to tackle drought, Afghanistan needs appropriate laws on forest conservation, utilization of underground water resources, land tenure and land taxes.

Most villagers felt that local shuras and water waqils (see annex 2), who were functioning well in the past, were not very effective in handling water issues, especially in the recent drought years. At the same time, people still feel that shuras can play a significant role in community-based drought management. Waqils are also suffering due to low production. Their income, often paid in kind by farmers, has reduced significantly. Consequently, they have lost interest in that work.

In the context of Afghanistan, livestock and rangeland issues are closely related to drought mitigation. During droughts, farmers often increase their reliance on livestock as a coping mechanism; because animals are a valuable asset, they can be moved when people are forced to migrate, and they can either be eaten or sold. Afghanistan farmers traditionally keep large herds,

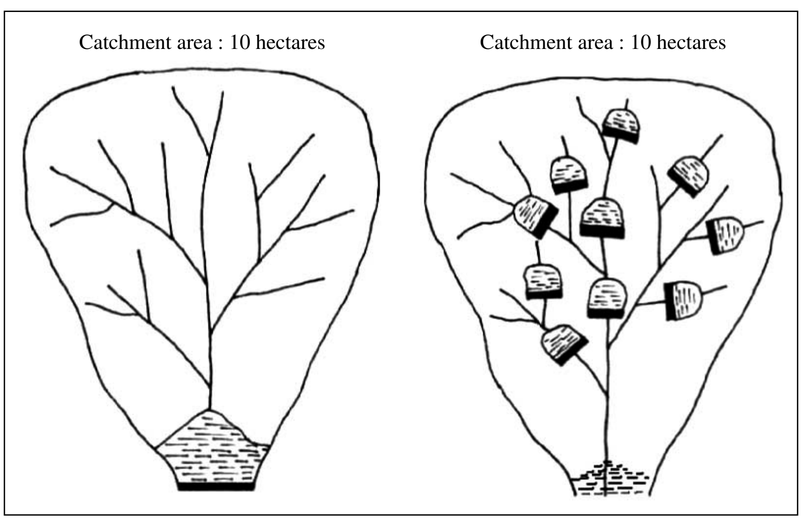

***Figure 4** : An illustration of a one-point catchment approach versus multiple point approach*

***Table 4** : Effect of catchment size on runoff water harvesting (Agarwal 2001).*

Size of catchment (ha)	Quantity of water harvested (m3/ha)	% of annual rainfall collected
Microcatchment: 0.1-1	160	15.2
20	100	9.52
300	50	3.33

Simple calculations can demonstrate the potential of rainwater availability if it is harvested efficiently. We use a scenario of 1 hectare of land located in Zaranj or Deshu, which are the driest places in Afghanistan with a rainfall of about 60 mm per year. The hypothetical maximum annual harvest with an assumption of zero losses will then be 600 m3. This should be enough to meet drinking and cooking water needs of about 110 people at a rate of 15 liters per person per day (SPHERE-Humanitarian Charter—standards and minimum standard in disaster response). Of course, it will not be possible to capture and retain all rainwater, as losses by infiltration and evaporation will be significant. One could still, even with a rudimentary technology, capture some 150 m3 of water per year (25% of the above: it has been shown by Maitra [2001] that, on a relatively plain area with little cultivation and light rains, the percentage of rainfall converted into surface runoff may be equivalent to 28%). This should be sufficient for 27 persons per year.

Table 5, compiled on the basis of statistics provided by AIMS, gives an estimate of areas required for micro-watershed water harvesting at 25% harvesting efficiency. The table takes into account only the settled population. Also, the 25% efficiency is still unlikely to be achievable in the conditions of high water losses in arid areas. It rather represents some theoretical maximum and more realistic efficiencies will be in the range of 1-10%. Due to the above, the area required to supply the same amount of water will increase proportionally. At the same time, even at low efficiencies of water harvesting, the positive side effects will be the additional recharge and enhanced vegetal cover for livestock.

***Table 5** : Area required for community-based water harvesting.*

River basins	Area (ha)	No. of villages	Average area of a village (ha)	Settled population (excluding nomads)	Average population per village	Average rainfall in the area (mm)	Area (ha/village) required to provide 15 l/ person/day at 25% efficiency
Amu-Darya	9,069,189	4,152	2,184	2,968,122	715	500	2.6
Harirod-	7,760,366	2,959	2,622	1,722,275	582	225	5.6
Murghab							
Helmand	26,234,136	14,041	1,868	5,881,571	419	150	6,2
Kabul	7,690,829	7,039	1,887	7,184,974	1021	300	8.0
Northern	7,090,127	2,969	2,388	2,783,033	937	300	6.8
Non-	6,735,636	69	97,818	151,629	2,197	175	
drainage							
Total	**64,580,283**	**31,229**	**2,068**	**20,691,604**	**663**	**250**	

Traditional Water-Harvesting Technologies

Apart from the micro-watershed water harvesting, which needs more insights and testing in the field, there is a strong tradition of innovative and effective small-scale water harvesting in Afghanistan and other arid areas of Asia. Large communities have survived in extremely arid environments of Asia through the ingenuous use of limited water resources. Such indigenous water-harvesting systems that deserve more attention at policy level include tankas (underground storage tanks widespread in arid areas of Rajasthan), khadins (small bunds in India within a catchment to retain rainwater and snow-melt), cha (already mentioned traditional systems in Afghanistan that collect snow in underground storage tanks), karezes (already mentioned underground tunnels to transport water across large dis-tances) and some others. These simple, but effectives, technologies are apparently rarely promoted or supported by governments or NGOs, according to interviewed farmers.

Conclusions and Recommendations

In the past decades, little research or few interventions were made in Afghanistan to combat drought. The institutional capacity is limited and there is an acute lack of data and knowledge on almost all aspects related to drought mitigation. A number of "needs assessment" projects have been con¬ducted in Afghanistan by many international and national organizations. They have set a solid start¬ing point on which to build specific interventions.

Irrigation water management is an important area which needs significant attention. Usually, the non-furrow flood irrigation method is employed for irrigating crops and fields. Hardly any water-saving techniques or devices are used. Relevant research, especially on its economics, to make the technology appropriate to small farmers, is long overdue.

Water waqils who were working efficiently earlier are not functioning because they are also suffering due to low production resulting in the reduction in their incomes. These village water institutions should be revived and maintained to ensure efficient water distribution.

As a significant proportion of livelihoods in Afghanistan is derived from livestock, rangeland and livestock management issues are closely related to drought mitigation and cannot be separated from water management.

Good steps already taken by the government (like the food security bulletin) will reach farmers only through a strong and efficient extension system, which currently does not exist and needs to be developed and strengthened.

Water transfers may be an option for mitigating drought in the long term by diverting excess water from a water-surplus river basin to a water-shortage river basin. However, before implementing such projects, detailed techno-economic, political and environmental feasibility studies need to be undertaken.

The traditional technologies of cha and karez should be rehabilitated along with health and hygiene education regarding the purification of water. In general, the rehabilitation of traditional methods of water management should be given priority. Farmers' age-old traditional knowledge should be rediscovered before or in parallel with introducing new, particularly large-scale and technologically advanced, projects.

It is important to consider ancient knowledge of clustering of micro-watersheds for local water supply. A micro-watershed approach may have a good potential in drought mitigation. Its proper utilization requires research supported by appropriate crop variety and animal breed selection. Currently, not much research has been done on these issues in Afghanistan.

In the studies and surveys made earlier, the views of women could not be captured properly. Recently, an organization has been located in Afghanistan that will undertake gender-related studies. Initial agreement has already been made and a questionnaire for surveying women's perception is being prepared.

One of the immediate possible actions is to arrange field trips to neighboring countries, e.g., western parts of Rajasthan in India, to show working water-harvesting technologies (tanka, khadins, etc.) to leaders in the arena of drought in Afghanistan and practitioners or farmers. Reverse field trips to Afghanistan to view karez and cha systems can also be useful. Cross-breeding of ideas may help in developing community-based drought-mitigation approaches in Afghanistan.

Annex 1

Effect of the current drought on different types of water bodies and structures (based on the information provided by FAO-Afghanistan).

Type of water resource/Province	Previous year	Present drought year	Reduction in the no. of wells	Reduction (%)
Shallow wells (no.)				
Farah	62	42	20	32
Gazni	59	50	9	15
Ghor	80	67	13	16
Helmand	60	54	6	10
Hirat	91	81	10	11
Kandahar	71	68	3	4
Khost	76	67	9	12
Nimroz	80	79	1	1
Paktia	54	43	11	20
Paktika	84	80	4	5
Urozgan	2	28	-26	-1,300
Zabul	31	24	7	23

Type of water resource/Province	Previous year	Present drought year	Reduction in the no. of wells	Reduction (%)
Deep wells (no.)				
Farah	74	77	-3	-4
Gazni	100	100	0	0
Ghor	0	0	0	0
Helmand	69	66	3	4
Hirat	87	84	3	3
Kandahar	69	65	4	6
Khost	54	50	4	7
Nimroz	50	50	0	0
Paktia	79	94	-15	-19
Paktika	71	71	0	0
Urozgan	80	69	11	14
Zabul	52	42	10	19

Type of water resource/Province	Previous year	Present drought year	Reduction in the no. of wells	Reduction (%)
Karez (no.)				
Farah	21	25	-4	-19
Gazni	31	26	5	16
Ghor	48	43	5	10
Helmand	38	35	3	8
Hirat	50	35	15	30
Kandahar	46	44	2	4
Khost	33	33	0	0
Nimroz	0	0	0	0
Paktia	34	38	-4	-12
Paktika	51	45	6	12
Urozgan	65	61	4	6
Zabul	24	21	3	13

Type of water resource/Province	Previous year	Present drought year	Reduction in the no. of wells	Reduction (%)
Springs (no.)				
Farah	100	93	7	7
Gazni	20	15	5	25
Ghor	48	48	0	0
Helmand	42	37	5	12
Hirat	60	38	22	37
Kandahar	25	30	-5	-20
Khost	63	56	7	11
Nimroz	0	0	0	0
Paktia	31	33	-2	-6
Paktika	42	73	-31	-74
Urozgan	53	40	13	25
Zabul	23	15	8	35

Type of water resource/Province	Previous year	Present (drought year)	Reduction (No.)	Reduction (%)
Hand pumps (no.)				
Farah	69	43	26	38
Gazni	98	95	3	3
Ghor	78	82	-4	-5
Helmand	76	65	11	14
Hirat	94	61	33	35
Kandahar	68	64	4	6
Khost	67	46	21	31
Nimroz	80	85	-5	-6
Paktia	71	57	14	20
Paktika	85	83	2	2
Urozgan	72	56	16	22
Zabul	36	35	1	3

Annex 2

Village Institutions in Afghanistan

Water Waqils

A water waqil (water judge) is selected by the villagers usually for a year for dealing with water-related issues. The waqil's main function is to ensure equitable distribution of water from the ca¬nal to the fields as per defined rules observed by the local community. For administrative prob¬lems related to canal water, waqils are always in touch with the Irrigation Department and with mirabs (water distributors) in villages. He can complain and take action according to the severity of offenses regarding violation of water rights. He supervises various works, e.g., desilting, con¬struction or repair of the canal. He is instrumental in choosing the families/laborers for these jobs. He makes frequent inspections and thereby exercises considerable power in maintaining canals. The waqil depends financially on the village community. He gets paid in kind from the produce of the communities that obtain water from the canal.

Shuras

A shura is an institution whereby members of the community select their leader(s) to represent them. A typical shura would include a Head, an Assistant, a Secretary and a few other members. Shura members are normally selected based on their commitment and they are usually elderly people of the village. The shuras are supposed to solve a variety of economic, cultural and civil prob¬lems, including rehabilitation of roads and canals, construction of bridges and schools, etc. The number of shuras in a village may be proportional to the village population. The shura is a reli¬gious and administrative entity. A shura head chairs all the village meetings, arbitrates the dis¬putes within a village, etc. For an outsider, the shura head is the top village functionary to get permission from for any kind of work. Shura heads are elected and sometimes this position may be hereditary. A shura head receives gifts from the community during festivals and also grows his own crop.

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Drought and Human Suffering in Afghanistan

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Background

It is a privilege for me to speak about a life supporting substance, such as water in a country that has experienced natural and man-made disasters for more than two decades.

The man-made disaster caused about 2 million of Afghans to lose their lives, 1 million to become disabled, 3 million to refuge to other countries; while the natural disaster, or the drought has forced about 700,000 people to be displaced from their areas to other places as well as the loss of life for a number of inhabitants. This is in addition to two major earthquakes that happened in year 2000 and caused more than 8,000 loss of life and displacement of more than 100,000 inhabitants of the area.

Afghanistan is a mountainous country with snow-covered mountains of high altitude, up to 7,500 m above sea level (asl). It has fertile valleys and large dessert plains. From topographic point of view, Afghanistan is classified into: low lands, (with 300 to 500 m elevation asl), medium lands (with 500 to 2,000 m elevation asl), and high lands (with altitudes higher than 2,000 m asl).

In terms of climate, Afghanistan is known by its continental climate. Nevertheless, the presence of mountains causes many local variations. The mountain ranges of Hindu Kush are normally moderate humid and covered by permanent snow and glaciers at altitude above 5,000 m asl. In these areas, temperature is low and precipitation occurs in the form of snow, whereas during summer, temperatures go high and virtually precipitation is nil.

Precipitation in Afghanistan is mainly correlated with altitudes. However, the presence of surrounding mountains in several regions (e. g., the Wakhan corridor and Bamyan highlands) alters this rule.

More than 50% of the country which is lower than 2000 m asl receive 100 mm to 300 mm of precipitation per year; while the remaining 50% of the country (except Ghore and Bamyan) receive 300 to 800 mm. Mansoon also influences in part the country during summers. This is evidenced especially in southeastern parts of the country.

In Afghanistan nearly 50% of precipitation occurs in winter (January to March); much in the form of snow; 30% in spring (April to June) and the remaining 20% during summer and autumn. Zaranj, in south-west the driest part of the country receives a normal long-term precipitation of 58 mm and most humid part of the country, i. e., South Salang, north-east receives 1023 mm of precipitation per year.
The cultivable land area has been estimated at 8 million hac, which is 12% of total area of Afghanistan. Out of this, 3.4 million hac is under cultivation. The total grazing area or pasture in the country is around 34.7 million hac. FAO/UNDP survey estimates the livestock population in 1995-1998 to 3 million cattle and 22.8 million

sheep and goat. The total evergreen forests in the southeastern part of the country were 2.2 million hac, i. e., 3.4% of the total territory prior to the war. However, the armed conflict associated with the lack of law enforcing institutions has caused this to reduce to only 2.2%.

Population of Afghanistan (projected from 1991 data) is regarded about 25 million inhabitants. In pre-war periods, about 85% of this number was dependent on agriculture. However, due to the current transient situation and the return of refugees, this data is in need of update.

Water Resources

Surface water

The river basin in Afghanistan can be divided into 3 major river basins. The Amu River Basin in the north is separated from the Sistan and Indus Basins by Hindu Kush mountains. Water catchment area of Amu River basin is estimated to 86,000 km^2. Sistan (Helmand) River Basin collects precipitation of an estimated catchment area of 418,800 km^2. The generated run-off from this basin some disappear in sandy dessert of the west, while the remaining drains in Hamoon-e-Helmand. Indus or Kabul River basin has an estimated catchment area of 140,160 km^2 and drains finally in Indian sea via Pakistan.

Groundwater

Afghanistan has huge reserves of groundwater bodies. According to FAO/UNDP estimates of 1996, the potential reserves of groundwater in the country is about 18 billion m^3 per year. Currently, about 3 billion m^3 is under usage, and up to about 8 billion m3 more can be explored. Recently, especially during the drought years, there has been a large development of groundwater use in agriculture and water supply in the country.
Hydrogelogically, Afghanistan is divided into 3 hydrogeological regions:

- Greet southern plains (Sistan Basin)
- Central Highland region or hydrogeologically folding region (Hindu Kush ranges in its broadest sense)
- Northern Plains (Amu River basin).

Great Sistan Plain is situated in the vast sand dessert between the rivers of Helmand-Arghandab and the boarder line with Pakistan in the west. Because of minimum precipitation and absence of surface water, the aquifer is very low productive and groundwater to be brackish to saline. Depth of water bearing strata in the basin varies from 50 to more than 100 m and the electro conductivity in some places exceeds 10,000 micromohs.

Highland Region in Afghanistan has 3 hydrogeological media. These are: the carbonate massive, the non.carbonate complex and intermountain structures. The carbonate massive is composed of limestone and dolomite locally interbeded with sandstone /conglomerate. Therefore, this structure is more or less karstified and there are occurrences of sinkholes, caves and various caverns.
The non-carbonate complex, which includes all pre-quaternary formations are of limited importance in terms of groundwater development aspect. Unfortunately, the largest part of the highland region consists of such formations.

Intermountain structural and river basins are of the highest hydrogeological significances in the highland regions. Either of the tectonic or erosion origin, they are in filled with alluvial and locally glacial deposits saturated with groundwater.

Northern Plains located in the narrow belt along the Amu River; composed of fluvial and delta deposits; saturated with fresh groundwater. Except for the hills of Hindu Kush Mountains, productivity of soil strata in terms of groundwater reserving is high.

Irrigation Systems in Afghanistan

Irrigation in Afghanistan is practiced by using both surface and groundwater.

Surface water is utilized for irrigation purpose in traditional and un-organized irrigation systems. Traditional irrigation systems are established for centuries back in Afghanistan. Maintenance and reconstruction are generally arranged on communal village basis. Technical knowledge and operational system are thus dependent on traditional community structures.

The organized or the formal irrigation system or the organized large-scale irrigation system in Afghanistan is relatively recent event. By late 1970s, five large-scale modern irrigation systems were built and were put into operation. These are the Helamnd irrigation system in the southwest, Nangarhar in the east, Sardeh in the south, Kunduz-Khanabad in the north and Parwan in central part of the country. The armed conflict and the drought have imposed great influences on these irrigation systems and have malfunctioned a number of them.

Groundwater resources are also widely used for irrigation purpose in Afghanistan.
As per collected data, more than 15% of Afghanistan's traditional irrigated land is fed from groundwater reservoirs. Water from this reservoir is discharged in springs, qanats and shallow wells.

Qanats are long tunnels dug horizontally in groundwater bearing formations of unconfined aquifers. They are like infiltration galleries, with a mother well on the uppermost and several access wells along its length. There are a total number of 6,741 qanats in the country that irrigate around 167,750 hac of land.

Springs are also water source of irrigation. About 5,558 springs are known to exist in Afghanistan. These springs feed around 187,430 hac of land.

Shallow wells are other water source for irrigation. As per available data, before the war, there were about 8,595 shallow wells for irrigation that could irrigate around 12,060 hac of land. But because of war and destruction of water supply systems in the country, an unpredictable tendency resulted in drastic increase in the number of shallow wells. Only in Kabul, there are about 130,000 shallow wells dug in private houses and public places for domestic water use.

Drought in Afghanistan

Background

Afghanistan is not regarded as drought prone country. However, droughts have been recorded almost everywhere in different years. The most relevant one was recorded in 1970-71 in almost all the country, but it particularly hit southwestern and northern regions. That drought resulted in displacement of population, loss of animals and sever food shortage. Other droughts happened in 1948 and 1955 in southern part of the country, 1961-62 in central parts and in 1973 in central and northern regions and in 1977 in northwestern regions. Minor droughts have been recorded in 198land 1992 in Ghazni, Ghore and Farah provinces.

The recent drought is the only one that has caused unrecorded impacts. The recent drought comparing with the previous droughts is multi-dimensional in its effect and severity. This worst drought has not been recorded in the last 50 years in Afghanistan. Drought occurred previously had affect only to some part of the country and had lasted for only maximum period of 2 years. But the current drought has so far continued for 3 to 4 years. This has affected rural and urban areas of Afghanistan, except for few places located in the valley along the perennial rivers.

The droughts recorded so far in the country can be categorized as:

- Local drought in small parts of the country; occurring each 3-5 years
- Regional (zonal) drought occurring each 9-11 years
- Countrywide droughts occurring each 20 to 30 years.

Effects of Current Drought Livelihood

Preliminary estimates suggest that the current drought has imposed negative impacts on at least half of population. 3 to 4 million people are affected severely; 8 to 12 million are under threat of famine and starvation. An estimated 700,000 people abandoned their houses in search of food, water and fodder (pasture); around 300000 have fled to neighboring countries and more than 400,000 people (IDPs) have moved to the closest and safest places. Figure 7 shown population movement inside and outside of Afghanistan.

Lack of water, food and shelter for IDPs has led to malnutrition, disease and death. According to available reports, the acute malnutrition rate among children under 5 years of age is 24.6% and mortality rate is recorded 2 people per 10,000 populations. Many of those who remained in their houses in drought hit areas are those inhabitants who could not manage to move to other places due to inability in covering transportation costs, lack of job opportunities, and mistreatment and abuse of refugees in the neighboring countries.

As per FAO/UNDP estimates in 1997, due to continued war and instability in the country, out of 3.4 million hac of arable land in Afghanistan, only 30% is estimated to be cultivated. 20% has poor on-farm water management, 10% is destroyed by war, 40% is damaged due to the lack of maintenance or abandoned by farmers.

In 2001, most of families consumed the seeds kept for sowing their land for the next year. Consumption of wild food (wild sugar beet and wild grass) is wide spread among the population of drought-hit areas. In some cases the situation is aggravated by the fact that districts has no road link and can only be reached on horse back or on foot.

Precipitation During the Year 2001

The winter 2001 witnessed around 5 to 20 % more snowfall than the year before. However, due to lack of spring rainfall and increase of air temperature, the snow reserves exhausted faster. At the beginning of spring, the river discharges were higher than the year before, but decreased drastically during spring.

The current drought has not much affected the discharge of main rivers with main discharge forming basin above 4000 m asl, but the discharge of tributaries with lower catchment area are affected. In these types of rivers, water can flow (lower than the normal discharge) up to the end of their normal destination. In territory of Afghanistan there is enough water for the land adjacent to these rivers, and no affect of drought has been seen in their valleys. But the drought affects are seen in the adjacent valleys, where the main rivers do not provide irrigation water but the tributaries.

The rivers with a main discharge forming catchment basin between 3000 to 4000 m asl have enough water in the upper and middle parts, however, in lower parts, shortage of water is observed noticeably. In all tributaries of these rivers shortage of water is acute.

The rivers with main discharge forming basins in an elevation lower than 3000 m asl an acute shortage of water is seen. In some cases, the groundwater table in the valleys of these rivers has declined. These types of rivers are mainly located in the northern, southwestern and southern part of the country.

All valleys and low land plains with an altitude lower than 2000 m asl except for the valleys of main rivers crossing the area, which consist most of the rain fed lands are seriously affected by the drought. According to reports from the field, all ephemeral rivers dried out in early spring and perennial rivers in early or mid summer. Perennial rivers such as Helmand river (mean discharge of 196.26 mVsec) in southwest, Farah Rud (mean discharge of 48.25 mVsec) in the west, Murghab River (mean discharge of 47 mVsec) in northwest and Kunduz River (original mean discharge of 106 mVsec) in the north can now be crossed by foot.

During the recent drought water level in the existing reservoirs of the country has reached to the critical and even some of them are dried completely. These reservoirs are Dahla in Kandahar, Qargha (Kabul), Band-e-Ghazi (Kabul), Sorkhab and Kharwar (Logar), Sultan and Sardeh (Ghazni).

The effect of drought in groundwater resources is also noticeable. As per an estimate, all traditional irrigation systems have reduced or dried up completely. 60 to 70% of Qanats are not currently in use and 85% of shallow wells were dried out. The main reason for low discharge or failure is the low groundwater recharge. In addition to this, boring of deep wells close to qanats and shallow wells imposed adverse effects on the discharge of these traditional irrigation systems.

Food Production and Demand

In year 2001, at the beginning of spring, the river discharges were higher than the year before and hence; about 14% higher wheat was harvested than year 2000. This amount is still 25% less than production in 1999. Due to the lack of rainfall, production of rain fed crops (wheat and barely) have reduced significantly, about 40% less than year 2000. In some parts of northern regions, the rain fed crops dried out completely. Due to 30% shortage of water flow in Kunduz river, a significant reduction in the cultivation of paddy has also occurred. It is worthy to mention that Kunduz valley in the north is one of the best and main rice producers in the country.

Grazing (pasture) and livestock

Nomads and farmers due to drought and acute shortage of fodders, low growth or drying up of pasture and lack of potable water in grazing area have sold or eaten an estimated 40%, in some case they have exhausted their herd. Movement of nomads has occurred earlier in 2001 than the previous year. This is due to drying up of low land pasture. The drought has paralyzed nomad activities as well.

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Drought Management Scenarios in Bangladesh

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Introduction

Climate change is happening now. The impacts of climate change and climate variability are global concerns, but in Bangladesh, where large parts of the population are chronically exposed and vulnerable to a range of natural hazards, they are particularly critical. Already, the human suffering and cost to development is massive to this country and its people are victims of human induced global warming. Three considerations are critical to understand how global warming and climate change will impact Bangladesh in future and influence its development. Firstly, the location of Bangladesh is in a deltaic plain of river basin, making it susceptible to different hazards. Secondly, the country is not only extremely populated having very small area but also possibly the most densely populated country in the world. Thirdly, majority of her population lives below subsistence level, making them already vulnerable as the country is also very poor.

Drought is a common hazard for Bangladesh. Bangladesh experiences a dry period for seven months, from November to May, when rainfall is normally low. In the country about 2.7 million hectares is severely drought prone causing hardship to poor agricultural laborers and others. Usually severe drought occurs in the north-western and south western region of the country. Droughts occurred in Bangladesh 24 times between 1949 and 1991. Very severe droughts hit the country in 1951, 1957, 1958, 1961, 1972, 1975, 1979, 1981, 1982, 1984 and 1989 (WARPO, 2005). About 47% area of the country and 53% of the population was typically affected by the pervious droughts. The food grain production lost in the 1978-79 droughts was probably 50 to 100 percent more than was lost in the great flood of 1974, showing that drought can be as devastating as a major flood or cyclone (Paul, 1998). Food grain off-take through the ration and relief systems averaged 227 000 tones per month in June to November 1979, compared to 169 000 tones per month from June to November 1974. Rice, jute and other crops were greatly affected although jute suffered the most because of lack of water for retting. Livestock also suffered, with many farmers having to sell their cattle at distress prices because they lacked fodder or needed cash to buy food which had increased in price because of scarcity. The widespread human distress resulting from reduced crops, reduced employment and incomes, and increased food prices was considerable. In the northwestern districts of Bangladesh the droughts of 1994-95 led to a 3.5 million tones shortfall of rice and wheat production.

Rice crop can be affected by drought in three different seasons, which accounts for more than 80 percent of the total cultivated area in the country. Droughts in March and April prevent timely land preparation and ploughing, delaying planting of crops during monsoon season. Insufficient rains in July and August delay transplantation of Aman in highland areas, while droughts in September and October reduce yields of both broadcast and transplanted Aman and delay sowing of pulses and potatoes. Boro, wheat and other crops grown in the dry season (summer) are also periodically affected by drought. Increased climate variability means additional threats to drought-prone environments and is considered a major crop production risk factor. It forces farmers to depend on low-input and low-risk technologies, leaving them unable to adopt new technologies that would allow them to derive maximum gains during favorable seasons and less able to recover quickly after disasters. Increasing climate risks undermine development and poverty reduction efforts in drought-prone areas. Future climate variability and change will intensify these problems even more in drought-prone areas of the country.

Agriculture remains the dominant sector of economy of Bangladesh, but its contribution to GDP has declined by about 50% compared to its contribution in 1970. The current contribution of GDP is around 20%. The sub sectors' contributions are also declining; crops around 12%, livestock about 3% and fisheries 5% respectively (Table 1).

Table-1 *: Contribution of Agriculture to GDP (%) at Constant prices (Base: 1995-96=100)*

Sector/ Sub-Sector	**Year**								
	1999-00	**2000-01**	**2001-02**	**2002-03**	**2003-04**	**2004-05**	**2005-06**	**2006-07**	**2007-08**
Agriculture	25.58	25.03	23.99	23.47	23.08	22.28	21.85	21.37	20.88
A. Crops	14.59	14.7	13.75	13.43	13.23	12.51	12.28	12	11.7
B. Livestock	3.02	2.95	2.96	2.93	2.91	2.95	2.92	2.88	2.79
C. Forest & related services	1.88	1.87	1.88	1.86	1.83	1.82	1.79	1.76	1.75
D. Fishing	6.09	5.51	5.4	5.25	5.11	5	4.86	4.73	4.64

Source*: Statistical Yearbook of Bangladesh 2007*

A major challenge for Bangladesh is to ensure food security for all remains in the wake of increased climate uncertainty. Impacts of climate change on food production are global concerns, but they represent a particular threat for Bangladesh. Agriculture, the food production sector, is already under pressure mainly due to an increase in demand for food, as well as to depletion of land and water resources. The potential of global climate change makes of this problem a priority for Bangladesh. Changing climate further threatens food security of huge population.

The adverse impacts of climate change in an already vulnerable country such as Bangladesh will put additional stress on overall development of the country. The issue has also been recognized at the higher political level of the country. To increase the resilience of the local community Government of Bangladesh (GoB) has taken appropriate strategies and implementing projects in order to reduce the potential threat of climate change.

Adaptation to climate change is one of the approaches considered likely to reduce the impacts of long-term changes in climate variables. Agricultural adaptation is the way for sustainable drought management. This paper provides current information of drought Impact and risk of Bangladesh along with some suggested management and policy interventions. It aims to provide direction on how the potential effects of climate change and adaptation options are responded by GoB. The climate change threat for Bangladesh is directly related to development. On the one hand development could facilitate the introduction of adaptation measures and on the other hand, it can also lead to further deterioration of the situation and thus increase the adverse impact of climate change.

Description

Drought:

Drought is primarily an agricultural phenomenon that refers to conditions where plants are responsive to certain levels of moisture stress that affect both the vegetative growth and yield of crops. It occurs when supply of moisture stored in the soil is insufficient to meet the optimum need of a particular type of crop. As a consequence of usual hydro-meteorological variability, drought occurs in pre-monsoon season when the potential evapo-transpiration (PET) is higher than the available moisture due to uncertainty in rainfall while in post-monsoon season it is due to prolonged dry periods without appreciable rainfall (Karim et al., 1990a). In both the seasons, due to sudden increases in temperature coupled with non-availability of rainfall causes a sharp rise in PET. One may relate to occurrence of drought with certain physical observations:

- development of continually broken cracks on the dried up topsoil,
- burnt-out yellowish foliage in the vegetation cover (top yellow syndrome), particularly observed in betel nut trees and bamboo groves, and
- Loosening of soil structure, ending up in the topsoil transforming into a dusty layer. Pre-monsoon drought is called Rabi and Pre-Kharif drought since it affects both Rabi and Pre-Kharif crops. Pre-monsoon drought is called Rabi and Pre-Kharif drought since it affects both Rabi and Pre-Kharif crops.

Critical dry periods in Bangladesh

The two critical dry periods in Bangladesh are kharif, and Rabi and pre-kharif:

(1) Kharif – droughts in the period June/July to October result from dry conditions in the highland areas especially in the Barind. Shortage of rainfall affects the critical reproductive stages of T. Aman rice, reducing its yield, particularly in those areas with low soil moisture-holding capacity. This drought also affects fisheries and other household-level activities.

(2) Rabi and pre-kharif – droughts in the period January to May are due to: i) the cumulative effect of dry days, ii) higher temperatures during pre-kharif (>40ºC in March/May), and iii) low soil moisture. This drought affects all the Rabi crops, such as boro, wheat, pulses and potatoes, and pre-kharif crops such as t.Aus, especially where irrigation possibilities are limited.

Northwestern regions are particularly vulnerable to droughts. A severe drought can cause more than 40 percent damage to broadcast Aus. Each year, during the kharif season, drought causes significant damage to the T. Aman crop in about 2.32 million ha. In the Rabi season, 1.2 million ha of cropland face droughts of various magnitudes. Apart from loss to agriculture, droughts have significant effect on land degradation, livestock population, employment and health. Between 1960 and 1991, droughts occurred in Bangladesh 19 times. Very severe droughts hit the country in 1951, 1961, 1975, 1979, 1981, 1982, 1984, 1989, 1994, 1995 and 2000. Past droughts have typically affected about 47 percent of the country and 53 percent of the population. The associated decline in crop production, losses of assets and lower employment opportunities contributed to increased household food insecurity. Food consumption fell, along with household ability to meet food needs on a sustainable basis. Vegetables and many other pulses are in short supply during drought in the country.

Water requirements for rice vary according to variety, but also soil type and season. Water needed for cultivating rice varies from 1000 to 1500 mm in heavy soils and from 1500 to 2000 mm in medium- to light-textured soil. The critical stages of the rice crop for water stress are tillering, panicle initiation, flowering and maturity. Adequate water needs to be maintained in the field during these stages. In the Barind tracts of Northwest Bangladesh, T.Aman rice grown during monsoon and boro rice during Rabi (winter) are prone to drought.

Drought Prone areas of Bangladesh

The major drought prone area of Bangladesh is Barind Tract. The Barind Tract is a distinctive physiographic unit comprising a series of uplifted blocks of terraced land covering 8,720 km2 in northwestern Bangladesh between the floodplains of the Padma (known as the Ganges in India) and the Jamuna rivers (the main channel of the lower Brahmaputra). Spread over parts of the greater districts of Rajshahi, Dinajpur, Rangpur, and Bogra of Bangladesh, and Maldah District of West Bengal in India, the Barind includes 773,000 ha in Bangladesh, of which 532,000 ha are cultivable. Rainfall is comparatively low in this region, with the long-term average being about 1,250 mm in the west and 2,000 mm in the northeast, occurring mainly from late April to October. With a variable rainfall and temperature ranging from 25 to 35 °C (regularly exceeding 40 °C) in the monsoon season, the area is considered semiarid and drought-prone. The Aman rice (monsoon)-growing season ranges from 180 days in the west to 220 days in the northeast but the frequency of dry periods, particularly in July and August, is the highest in the country. The Barind is at a comparatively higher elevation than the adjoining floodplain and there are two terrace levels—one at 40 m above sea level and the other between 19.8 and 22.9 m. Therefore, when the floodplains go under water during the monsoon, the Barind Tract remains relatively free from flooding and is drained by a few small streams. About 47% of the Barind region is classified as highland, about 41% as medium highland, and the rest is lowlands. Although 55% of the Barind was forest in 1850, subsequent rapid population growth resulted in 70% of the land being converted to arable land by 1970. The area is now characterized by terraced slopes with bunded fields without water control other than drainage by gravity to lower-lying fields and streams. The High Barind Tract, lying in Rajshahi, Chapai Nawabganj, and Naogaon districts, is one of three distinct areas of the Barind, occupying 160,000 ha, roughly 21% of the region. This is the most marginal area of the Barind Tract for rain fed cropping, accounting for 12% of the drought-prone lowland rice land in Bangladesh. (Riches et al., 2008).

Soil Resource Development Institute (SRDI) has identified and mapped the drought prone areas of Bangladesh for the main cropping seasons in the country (Figure 1). Areas of Bangladesh that are affected by drought during the different crop seasons are given in Table 2.

***Table-2**: Drought affected areas by cropping season*

Crop season	Area under various drought severity class (in million ha)					
	Very severe	Severe	Moderate	Slight	Unaffected	Non-T. Aman
Pre-Kharif	0.403	1.15	4.76	4.09	2.09	-
Kharif (T. Aman only)	0.344	0.74	3.17	2.90	0.68	4.71
Rabi	0.446	1.71	2.95	4.21	3.17	-

*(**Source**: Iqbal and Ali, 2001).*

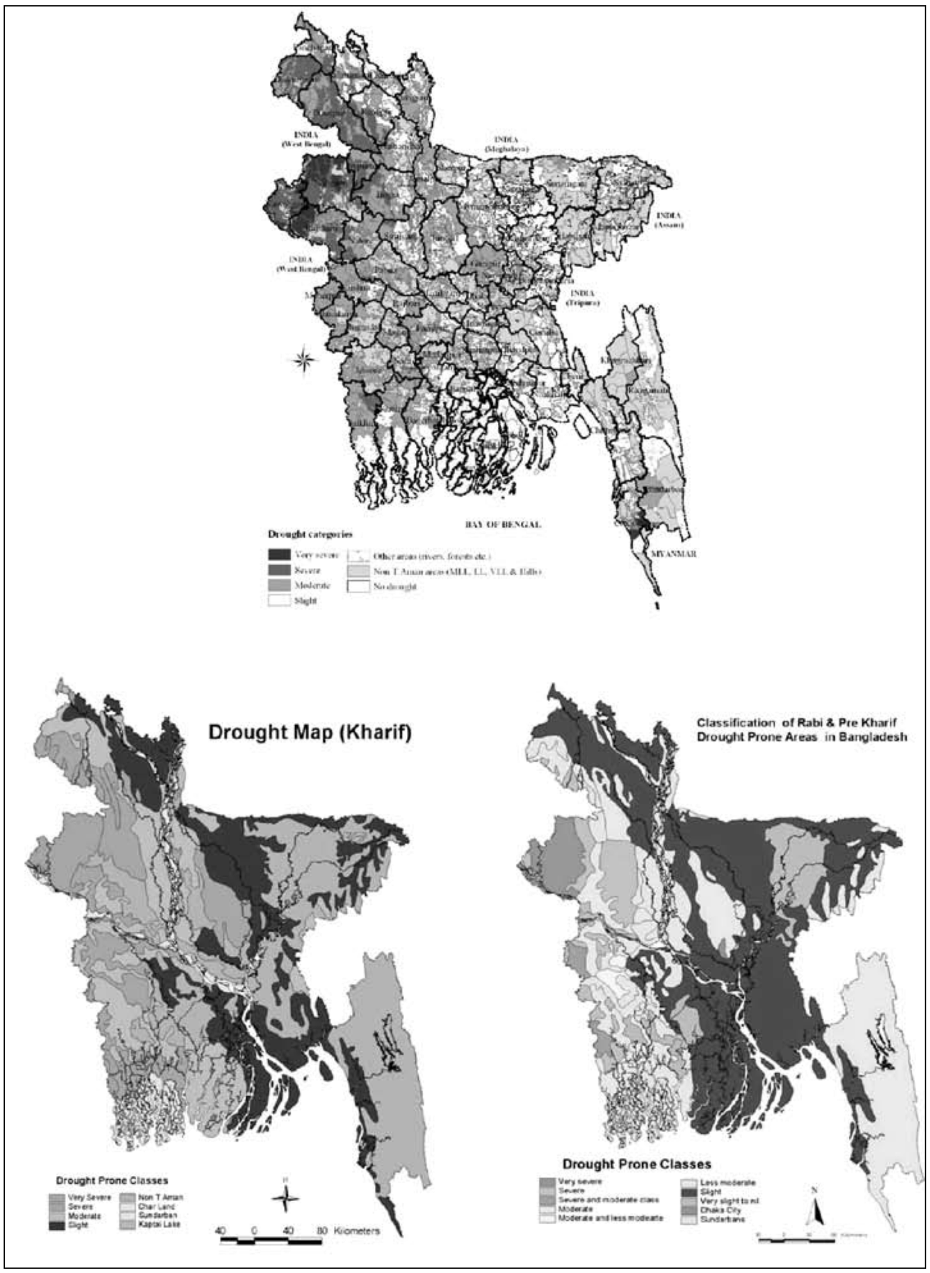

***Figure 1**: Drought prone areas in Bangladesh (Source: SRDI)*

Chronology of major drought events and its impact in Bangladesh in deferent years (Selvaraju et al, 2006)

1791 : Drought affected Jessore district, prices doubled or tripled.

1865 : Drought preceded Dhaka famine.

1866 : Severe drought in Bogra, rice production of the district was hit hard and prices tripled.

1872 : Drought in Sundarbans, crops suffered greatly from deficient rainfall.

1874 : Extremely low rainfall affected Bogra, great crop failure.

1951 : Severe drought in Northwest Bangladesh substantially reduced rice production.

1973 : Drought responsible for the 1974 famine in northern Bangladesh, one of the most severe of the century.

1975 : Drought affected 47 percent of the country and more than half of the total population.

1978-79 : One of the most severe droughts in recent times with widespread damage to crops reducing rice production by about 2 million tonnes, directly affecting about 42 percent of the cultivated land and 44 percent of the population.

1981 : Severe drought adversely affected crop production.

1982 : Drought caused a loss of rice production of about 53 000 tonnes while, in the same year, flood damaged about 36 000 tonnes.

1989 : Drought dried up most of the rivers in Northwest Bangladesh with dust storms in several districts, including Naogaon, Nawabganj, Nilpahamari and Thakurgaon.

1994-95 : The most persistent drought in recent times, it caused immense crop damage, especially to and rice and jute, the main crops of Northwest Bangladesh and to bamboo clumps, a main cash crop in the region.

1995-96 : Droughts cause major deterioration in household health because their subsequent impact of reducing food consumption leads to substantial increases in illnesses. Drought also leads to an increase in severe chronic energy deficiency among members of the agriculture work force.

Main Problems of Drought Prone areas (High Barind Tract) in Bangladesh

Topography

The High Barind Tract has a distinctive topography with pronounced differences in land height. Higher land holds water for less time and dries out more quickly, making it more risky for rice and less suitable for rabi crops that rely on residual soil moisture

Land tenure System

Most of the land is rented on a sharecropping basis for Rice cultivation in monsoon season, wherein the risk is shared equally between the landlord and tenant, rather than on a fixed-rent basis wherein the risk is borne entirely by the tenant.

Changing Rainfall Pattern

The optimum time for transplanting is mid-July but erratic rainfall delays transplanting. So, drought can either delay or damage transplanted rice. A two-week period without rain during the grain-filling stage occurs once every two years (Saleh et al 2000).

Improper Water Harvesting

There are several ponds in High Barind Tract but all ponds have poor capability of water storage capacity. Due to lack of proper water harvesting, farmers of Barind Tract do not cultivate in most of the lands in dry periods.

Low soil fertility

Soil patterns are complex, often varying within the same field (Brammer 1997). The gray terrace soils of the High Barind have low organic matter (0.8–1.2%).

Life Cycle of Rice variety

The main variety of transplanted rice is Swarna, but the life cycle of Swarna variety is 150–155 days. Swarna gives a high yield, but its long field duration reduces the chance of there being sufficient soil moisture after harvest with which to sow a rabi crop.

Subsistence pressure

Land pressure, poor soils, and sharecropping both create and reinforce subsistence pressure on small farms and place a premium on achieving household food security.

Drought Impacts on Crops

Droughts are adversely affects rice crops, which account for more than 80% of the total cultivated land of the country, and also causes regular damage to jute, the country's main cash crop. Drought refers to a condition when the moisture availability at the root zone is less than adequate. It is often observed when there is extremely high rate of evapo-transpiration or high index of aridity. As the evapo-transpiration of soil becomes high, it forces the soil to be unsuitable for plant growth. This is how Aman cultivation suffers from periodic drought conditions (Karim et al., 1999).

Although 80% of the annual rainfall occurs during May to September, long spells of rainless days ranging upwards from two weeks can cause drought. Land preparation and ploughing activities hampered when drought comes in March and April, delaying the broadcasting of Aman and the planting of Aus and Jute. Drought in early pre-Kharif months, affecting Boro and wheat cultivation. When droughts occur in May and June, they destroy broadcast Aman, Aus and jute. Inadequate rains in July and August delay transplantation of Aman, while droughts in September and October reduce yields of both broadcast and transplanted Aman and delay the sowing of pulses and potatoes.

Major droughts occurred in different years causing substantial reduction in food production. The consecutive droughts of 1978 and 1979 directly affected 42% of cultivated land and reduced rice production by an estimated 2 million tons.1 The losses due to drought in 1982 were more than double the losses caused by floods in the same year. The 1997 drought caused a reduction of around 1 million tons of food-grain, of which about 0.6 million tons is transplanted Aman.

Devastating and regular droughts caused by a lack or a late/early arrival of rainfall happens very often in many parts of Bangladesh, badly affecting agriculture. Drought impact, associated with late or early monsoon rains or even complete failure of monsoon, spreads over a much larger geographical area than areas affected by other natural hazards. (Selvaraju et al, 2006).

Drought Management

Institutional responses to mitigate drought

Various formal institutions of the country in responding to mitigate drought in the country.The Livelihood Adaptation to Climate Change (LACC) Project is a sub-component of the Comprehensive Disaster Management Programme (CDMP), long-term programme of the Ministry of Food and Disaster Management. It started its operation in the north-west drought prone region of Bangladesh in 2005 to 2010 has been executed by the Ministry of Agriculture, Department of Agricultural Extension (DAE) and technically guided by the Food and Agriculture Organization of the United Nations (FAO). The project implemented activities to promote livelihood adaptation and reduce vulnerability to climate change of poor communities who have the lowest capacity to adapt. Different tested options in drought prone areas are given below;

Categories	Tested Adaptation Option/ Technology/Practice	Agro-ecological context	Source of the option	Farmers' Acceptance
Agronomic management	Mango orchard management	Rain fed and Irrigated	Community and DAE	High
	Dry seedbed method for raising seedlings for T. Aman rice cultivation	Rain fed	Farmers and experts	Moderate
	Cultivation of Aromatic (Chini Atap) rice varieties	Irrigated	Community and DAE	Moderate
	Cultivation of short duration rice varieties (Block demo)	Rain fed	Community and DAE	Moderate
	Cultivation of Aus (Early monsoon) rice	Rain fed	Community and DAE	Moderate
	Impact of water saturated soil condition on rice cultivation/water saving rice cultivation (SRI)	Irrigated	Experts	Low
Water harvesting	Supplemental Irrigation	Rain fed	Farmers, DAE	Very high
	Excavation of Mini Ponds for supplemental irrigation	Rain fed	BMDA	Very high
Water use efficiency	Cultivation of wheat	Irrigated	DAE, Community and Experts	Moderate
	T. Aman – Chickpea/mustard/linseed system	Rain fed	Research institutes	High
	T. Aman – Mung bean system	Rain fed	Research institutes	High
	T. Aman – Chickpea and barley system	Rain fed	Research institutes	Moderate
	T. Aman – Chickpea and coriander system	Rain fed	Research institutes	Moderate
	T. Aman – Linseed and barley system	Rain fed	Research institutes	Moderate
	T. Aus – Chini atap system	Rain fed	Farmers	Moderate
	Green Manure – T. Aman system	Rain fed	Farmers	Moderate
	Sesame cultivation	Rain fed	Community and DAE	Moderate

Categories	Tested Adaptation Option/ Technology/Practice	Agro-ecological context	Source of the option	Farmers' Acceptance
Alternate enterprise/ crops/technologies	Mango gardening	Rain fed	Farmers	Very high
	Maize cultivation	Rain fed	Farmers	Very high
	Homestead vegetable cultivation	Rain fed and Ir-rigated	BARI	Very High
	Jujube gardening	Rain fed and Ir-rigated	Experts	Very high
	Litchi gardening	Rain fed	Community and DAE	High
	Mixed fruit gardening	Rain fed and Ir-rigated	Community	High
	Duck rearing	Rain fed and Ir-rigated	Community	High
	Fish rearing in mini pond	Rain fed	Community and DoF	Moderate
	Fruit tree plantation in the homestead	Rain fed and Ir-rigated	Community	Moderate
	Sheep rearing	Rain fed and Ir-rigated	Community and BLRI	Moderate
	Fodder cultivation	Rain fed and Ir-rigated	DAE, DLS and Research institutes	Moderate
	Mini nursery establishment	Rain fed and Ir-rigated	Community and DAE	Low
	Papaya cultivation	Rain fed and Ir-rigated	Farmers	Low
	Silage preparation with mung bean/maize	Irrigated	Research institutes	Low
Alternative energy source	Biogas plant establishment	Rain fed and Ir-rigated	Experts	High
	Fuel, timber and fruit tree plantation along the roadside, khari canal	Rain fed and Ir-rigated	Community	Moderate
Household level energy efficiency	Improved cooking stove	Rain fed and Ir-rigated	Experts	Very high
Soil health improve-ment and energy saving	Farm yard manure (FYM) preparation	Rain fed and Ir-rigated	DAE	High
	Cultivation of green manuring crops	Rain fed	Community and experts	Moderate
Institutional adjustment/ commu-nity approach	Community based vegetable cultivation	Rain fed and Ir-rigated	Community and DAE	High
	Timber, fruit and medicinal tree plantation along the khari canal in the Barind area	Rain fed	Community and DAE	High
	Community based pigeon pea cultivation along the khari canal	Rain fed	Community and DAE	High
	Community based Palmyra palm plantation along the feeder road	Rain fed	Community and DAE	Moderate
	Community based goose rearing	Rain fed and Ir-rigated	Community and DAE	Moderate

Barind Multipurpose Development Authority (BMDA)

The Barind Integrated Area Development Project (BIADP), later renamed the Barind Multipurpose Development Authority (BMDA), was established in 1985 to retain environmental balance and check the desertification of the Barind region's Rajshahi, Naogaon and Chapai Nawabganj districts. Before the project activities started, the Barind Tract was the most unfavorable agricultural section of the country where rain fed local T. aman was the dominant crop. Now, the ensured supply of deep tube well (DTW) irrigation has fundamentally changed the Barind Tract's agricultural scenario.

In place of a single crop, multiple crops are grown with higher agro-economic productivity.

Ongoing projects of the BMDA include:

- Installation of DTWs,
- Construction of irrigation canals and roads,
- Electric connections for the DTWs,
- Re-excavation of ponds
- Afforestation,
- Drinking water supply through the DTWs and
- Production of fine and aromatic rice,etc.

Several other agencies such as Disaster Management Bureau (DMB), Department of Relief (DoR), Ministry of Environment and Forests (MoEF), Department of Environment (DoE), Ministry of Agriculture (MoA), Department of Agriculture Extension (DAE), Department of Livestock (DoL),Department of Fisheries (DoF) and different NGO's are also involved in the process of drought risk management and finding viable adaptation options for drought-prone areas. Research agencies such as Bangladesh Rice Research Institute (BRRI), Bangladesh Agriculture Research Institute (BARI), International Rice Research Institute (IRRI) and Bangladesh institute of Nuclear Agriculture (BINA) have been involved in the demonstration process.

Recommendations

Ensuring community participation in drought management, in addition to top down institutional development and policy support is crucial to manage the future risks at community level in general and for the agriculture sector in particular. Recommendations for drought as well as Climate Risk Management (CRM) are:

- Develop seasonal climate predictions to assist farmers to optimally adjust their planting dates, crop varieties, and management practices to reduce agricultural vulnerability to hydro meteorological hazards.
- Establishment of a regional early warning system, information sharing, by regular surveillance and forecasting and communication to local stakeholders in order to improve the adaptive capacity of communities.
- Share information on management of climate change and related science, data, tools and methodologies in South Asia.
- Establishment of drought Management Centre or drought-monitoring centre
- Expansion of Climate Change related projects
- Capacity building on drought management
- Improvement of collection and dissemination of weather-related information by improving weather station networks to strengthen monitoring of extreme events and their impacts on food production and availability.

- Improving national agricultural extension services in order to secure farmers' self- reliance by providing better information about effective weather and climate risk management and the sustainable use of natural resources for agricultural production.
- Designing academic curricula and courses to provide target-specific training on climate issues.
- Research and popularization of drought tolerant crop varieties in vulnerable areas.v
- Popularization of, where applicable, simple and affordable irrigation techniques and with reference of meteorological services development of suitable sowing date for local crops and also altering the timing of planting dates to adapt in changing growing conditions.
- Conservation and management of rainfall water through small dams.
- Conserving soil moisture through mulching and other means.
- Development of rain fed cropping system (cash crops at small scale).
- Providing Agriculture risk insurance.
- Develop seasonal climate predictions to assist farmers
- Establishment of a regional early warning system
- Agricultural research especially in the area of new variety development those are suited to the changing mode of drought and climatic parameters like temperature, rainfall pattern, foggy weather etc.
- Enhance irrigation and water use efficiency by introducing crops requiring less water and technologies that ensure efficient use of irrigation water in the cultivation practices.
- Regional co-operation on climate change adaptation and mitigation
- Disaster Management, Emergency Relief and Social Safety Net measures
- Restoration of wetland and increasing water storage capacity and connectivity of river systems
- Conservation of forest and wetland resources
- Information and Knowledge management
- Development of reference data base system
- Political will
- Reforms of Policy and Mainstreaming Climate Risk Management (CRM)

Conclusion

Bangladesh is highly sensitive to climate variability and change impacts on the agriculture sector. The key risks from climate change to agriculture and allied sectors in northwestern Bangladesh are related to increased drought frequencies (kharif II) and inadequate availability of water for irrigation (rabi). Agriculture depends on freshwater resources and, thus, depends on the success of adaptations in that sector. The agriculture sector must have increased productivity. Crops need to be diversified and, thus, less vulnerable to changes in market conditions and climate. Adaptation practices related to new cropping systems involving drought resistant crops will benefit the sector as a whole.

In fact, with successful adaptation, the production of major crops would not be threatened by climate change. For ensuring our food security successful local level disaster risk management that integrates climate change adaptation requires multiple pathways of well-planned and interrelated short-term and long-term measures. Different physical adaptive measures, adjustment of existing agricultural practices to match future anticipated risks, adjustment of cropping pattern, selection of adapted varieties of crops; diversification of cropping and/or farming systems; better storage of seeds and fodder; dry seed beds; switch to alternative crops; more efficient use of irrigation water on rice paddies; more efficient use of nitrogen application on cultivated fields; improved water management including water harvesting, and savings practices ;traditional water bodies, canals, and ponds need to be dredged and re-excavated to enhance water storage and drainage capacities, more agro forestry practice, strengthening of formal institutional structures and environment; awareness creation and advocacy on drought and disaster risk management, linking climate change and adaptation issues; and policy formulation to catalyze enhancement of drought risk management and adaptive livelihood opportunities. A drought-monitoring centre with responsibility for collecting climatic change and water balance data should be established in Northwest Bangladesh in order to alleviate the effects of drought with an understanding of how and why drought occurs and be prepared to undertake appropriate mitigation programme.

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Current Status on Drought Risk Management in India

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Drought is a common widespread natural disaster. Almost one half of the countries of the world are situated in drought risk areas in Africa, Asia, Australia, North America and South America. Effect of drought is mainly felt on agricultural production and in availability of water for domestic and industrial consumption. Impact of drought creeps in slowly but has a long lasting effect on the country's economy.

India is located in South Asia, which has a distinct geographical identity. Most of the region of the South Asian subcontinent is resting on the Indian Plate (the northerly portion of the Indo Australian Plate) separated from the rest of Eurasia. Between the Himalayas and the Indian Ocean, the region houses a variety of astonishing geographical features like seas, glaciers, rainforests, valleys, deserts and grasslands that are typical to much larger continents. Varying climatic conditions exist in the region, from the tropical South to the temperate North. For the most part, however, the climate of the region is called Monsoon climate. The region is the home of the world's largest habitation of human population, majority of which is dependent on agriculture for livelihood and, therefore, is vulnerable to risks in terms of sudden fluctuations in weather conditions. Also, the region is marked by high disparities in income, health and educational status of people.

Meteorologically, India is divided into 36 Sub-Divisions. For the purpose of agricultural planning and development, the country is divided into 127 agro climatic zones depending on the temperature, quantum of rainfall, soil and cropping pattern. Drought is a normal recurrent feature of Indian climate and is usually characterized in terms of its spatial extension, intensity and duration. Unlike other natural disasters, it has a slow onset but grows in intensity with devastating effect. The key drought indicators are Rainfall, Water Storage Levels in Reservoirs, Surface and Groundwater Levels, Sowing and Crop conditions. The impact of drought is generally categorized as economic, environmental and social.

The South-West Monsoon Season (June – September) is the main rainy season in India, when about 73% of the country's annual rainfall is realized. Hence, the failure of SW Monsoon manifests as drought. Around 68% of the land area in India is prone to drought of varying degrees. In the entire country, 35% of the area receiving rainfall between 750 mm and 1,125 mm is considered drought prone, while another 33% receiving less than 750 mm of rainfall is considered chronically drought prone. Accordingly, drought-prone areas account for a total land area of 329 million hectares, which are classified into arid (19.5%), semi-arid (37%) and sub-humid areas (21%).

Drought has widespread impact on the nation's life cycle, much beyond the areas actually experiencing physical drought. Although agro-based sectors are primarily affected by drought conditions, the secondary effects of drought are also felt on other sectors like hydro-power generation, agro-based industries, availability of drinking water etc. Drought makes severe impact on population, more so, where the livelihood is basically dependent upon agriculture and related occupations. The agricultural income shrinks and causes loss of employment primarily in the rural areas thereby affecting the economic cycle. Most major droughts in India were followed by recession. Though drought makes its impact slowly over a period of time, it ultimately poses a serious challenge to human well being for a prolonged period of time.

Historical background of drought management in India

Post-Disaster Relief Approach – Pre-1947: India witnessed more than 25 droughts during pre-Independence period. The abnormal climatic conditions, lack of water and land management policies coupled with lack of administrative abilities and colonial apathy turned the impending drought conditions into famines. On the basis of the recommendations of the Royal Famine Commission instituted in 1880 to examine the cause of famine and also of the subsequent Commissions on famine, the Indian Famine Codes were evolved for famine relief. During this period, the focus was on minimizing starvation deaths through 'Test Relief' and free kitchens. Relief interventions were initiated on evidence of actual distress (migration), rise in crime and increased cattle mortality. Thus, management of drought during this period was essentially post -occurrence of the calamity.

Post-Disaster- Relief & Rehabilitation Approach - 1947 to 1965: Post-Independence, there was a sweeping change in the approach for drought mitigation with the focus mainly on addressing the negative impact of disaster, primarily on agriculture. India adopted Five Year Planning Programme after Independence and greater importance was attached to agricultural growth in the Five Year Plans. The focus during this period was on prevention of destitution, which was initiated on indications of crop failure with or without actual distress mainly through distribution of Gratuitous Relief or cash doles to provide immediate relief assistance on onset of scarcity (full blown drought) to prevent famine.

Pre-Disaster - Prevention & Mitigation Approach – mid 1960s to 90s: During this period, the focus was on drought management through long and short-term development programmes with prevention and mitigation approaches. Steps were taken to implement development programmes having built in mechanism for preventing drought and other natural disasters, particularly on the agricultural front. Further, livelihood security was ensured through relief works initiated at the end of the monsoon season and Public Distribution System (PDS) was implemented on large scale to maintain food supply at affordable rates resulting in avoidance of migration of labour/ rural poor in the event of any failure of monsoon.

Pre-Disaster - Management Approach –post-1991: After the major drought in 1987, the need was felt for continuous and coordinated management of drought through close monitoring and implementation of contingency plans to minimize economic losses on account of drought. Accordingly, key indicators of impending drought were monitored through setting up of Crisis Management Group, Crop Weather Watch Group, Inter-Ministerial Group etc. Before the onset of monsoon, the prevailing weather and climatic conditions are analysed and requisite preparedness measures taken through coordinated management by different Ministries / Departments. Besides, contingency plans for crop, water, health, power and other relevant sectors are prepared and updated. Advisories are issued on the basis of these plans to the 'user groups' for effective tackling of deficit hydrological conditions. Fortnightly Aridity Anomaly Report is prepared and released by the Drought Research Unit of India Meteorological Department (IMD) for concurrent evaluation of drought like conditions by the respective government agencies. Besides soil moisture stress and vegetation status are analysed by the National Agricultural Drought Monitoring and Assessment System (NADAMS) of the National Remote Sensing Centre (NRSC) and the status is made known to the government agencies for taking appropriate risk reduction measures. Major droughts of 2002 and 2009 were managed on this pro-active approach. The thrust is now on real time monitoring and analysis of the indicators of drought to formulate strategy and prepare contingency plans and take market stabilization measures in order to sustain agricultural production. Drinking water mobilization, feed and fodder management, special schemes on employment generation etc. are carried out to preserve quality of life in chronic drought prone areas.

Although the history of drought management in India dates back to the medieval period, the droughts experienced during colonial period were the most severe which turned into severe famines resulting in heavy loss of human lives. The most devastating were the recurrent Bengal famines, which affected millions of human population and wiped out domestic animals. The situation has improved remarkably since Independence. The Green Revolution in the late 1960s made the country self-sufficient in food production. The new pro-active approach now being adopted by the Government has helped in mitigating the impact of drought on the quality of life. Though India's population has tripled during the last 60 years, there has not been any famine which is a testimony of effective public policy and management strategies adopted in the country to tackle natural calamities.

Managing drought risk

Risk management approach is adopted for managing uncertainty and potential losses and it involves assessment and analysis of risk to facilitate development of strategies and specific action plan to control and reduce risks and losses. Risk arising out of climatic hazards can be addressed by taking preventative measures by issuing early warning and adopting appropriate response measures to manage extreme events including drought. Managing drought, like other natural calamities, depends on how exactly early signs of the impending disaster are picked up, assessed and evaluated, based on which appropriate steps are taken for managing the crisis situation, as represented diagrammatically in Figure-1.

Figure-1: *Managing Risk*

Drought 2009 - An Overview

Rainfall during SW Monsoon 2009

The India Meteorological Department (IMD) made a forecast in Apri'2009 of normal rainfall during the season in the country with 96% ± 5% of Long Period Average (LPA). The South West monsoon in 2009 set in on 23rd May in the southern part of India in Kerala about one week in advance. However, the advancement of monsoon in the country soon stagnated for about 10 days and then it regained advancement northward with reduced rainfall. The deficit rainfall was evident for the entire country right from the first week of June, 2009 and reached a peak of - 54% for the period ending 24th June 2009. In June IMD reassessed the situation and corrected their forecast to 93%± 4% of LPA. However, actual rainfall in the country as a whole during the season (June-September-2009) was 78% of its LPA. In other words, there was overall deficit in rainfall by 22%. The rainfall distribution during this period, for the country as a whole and region-wise is depicted at Table-1

***Table 1** : South West Monsoon 2009 - Actual Rainfall & Percentage Departure from LPA*

Region	Actual(mm)	LPA (mm)	% of LPA received	% Departure
All-India	698.1	892.2	78	-22%
Northwest(NW) India	392.1	611.7	64	-36%
Central India	795.4	995.1	80	-20%
South Peninsula	692.9	722.5	96	-4%
Northeast(NE) India	1037.7	1427.3	73	-27%

Out of 36 Meteorological Sub-Divisions in the country, 3 Sub-Divisions received Excess rainfall (+20% or more), 10 received Normal rainfall (+19% to -19%), 23 received Deficient rainfall (-20% to -59%) and none received Scanty rainfall (-60% to -99%). The South-West Monsoon was not only weak, it was also erratic i.e. its spatial distribution was uneven and at times with long dry spells in between during the season. Month wise cumulative departure in rainfall is given at Table-2.

***Table- 2**: SW Monsoon 2009 Month-wise Cumulative Rainfall*

Regions	% Departure (1 June - 30 September)			
	1 June to 30 June	1 June to 31 July	1 June to 31 Aug	1 June to 30 Sept
Country as a whole	-48	-21	-23	-22
Northwest India	-46	-34	-38	-35
Central India	-60	-03	-17	-20
South Peninsula	-32	-15	-14	-6
North East India	-47	-38	-25	-23

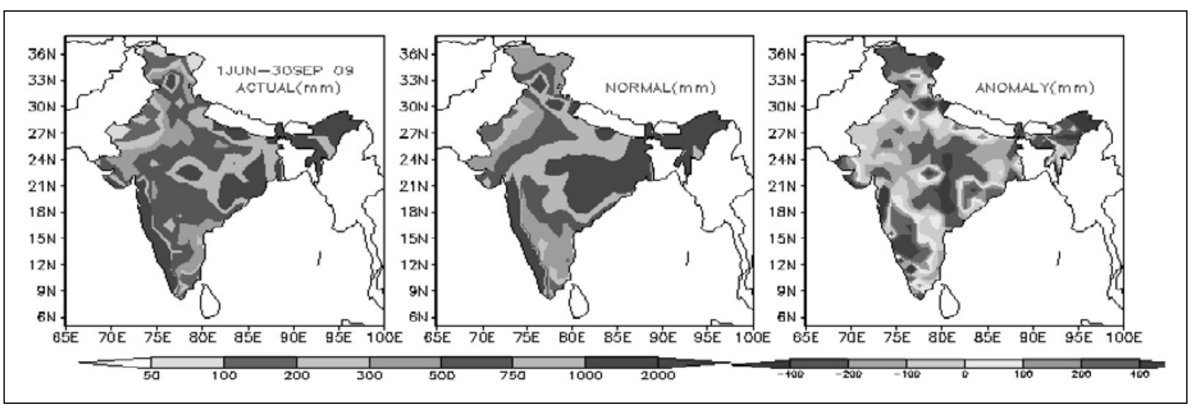
The monthly monsoon rainfall over the country as a whole during the months of monsoon was below the respective Long Period Average forecast. In June, it was 53% of LPA, in July it was 96% of LPA, in August it was 73% of LPA and in September it was 79% of LPA, as shown at Table-3.

***Table 3** : SW Monsoon 2009 - Long Range Forecast & Actual Rainfall*

Region	Period	Issued on	Forecast	Actual
All India	**June to September**	**17 April, 2009 24 June, 2009**	**96% ± 5% of LPA 93%± 4% of LPA**	**78% of LPA**
All India (Month-wise)	June			53% of LPA
	July	24 June, 2009	93%± 9% of LPA	96% of LPA
	August	24 June, 2009	101% ± 9%of LPA	73% of LPA
	September			79% of LPA
Northwest India	June to September	24 June, 2009	81% ± 8%of LPA	65% of LPA
Northeast India			92% ± 8%of LPA	77% of LPA
Central India			99% ± 8%of LPA	80% of LPA
South Peninsula			93% ± 8%of LPA	94% of LPA

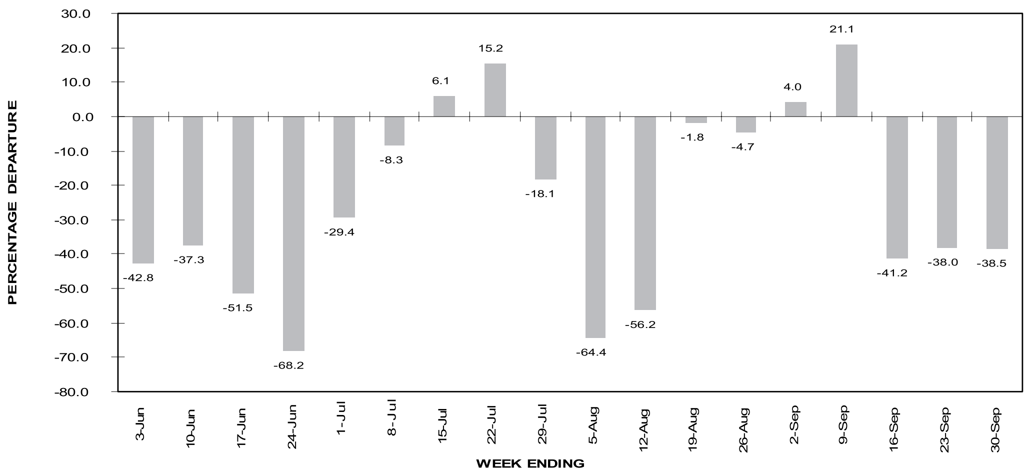
There was large rainfall deficiency over most parts of the country due to prolonged hiatus in the advancement of monsoon over central and northern parts of the country. During July, the rainfall over most of the Meteorological Sub-divisions along the foothills of Himalayas and few in the eastern side of the Peninsula was highly deficient. In August the rainfall over most of the subdivisions along the west coast, North West India & neighboring Central India was highly deficient. In September the rainfall over all subdivisions in the South Peninsula & neighbouring Central India and a few subdivisions in the North was excess or normal resulting in flood, as in Karnataka, Goa, Andhra Pradesh, etc.. Rainfall over other subdivisions was deficient or scanty. The Accumulated Seasonal Rainfall Anomaly in the country during the south west monsoon is represented in the Map-1.

***Map -1**: Accumulated Seasonal Rainfall Anomaly Map (during SW Monsoon - 2009)*



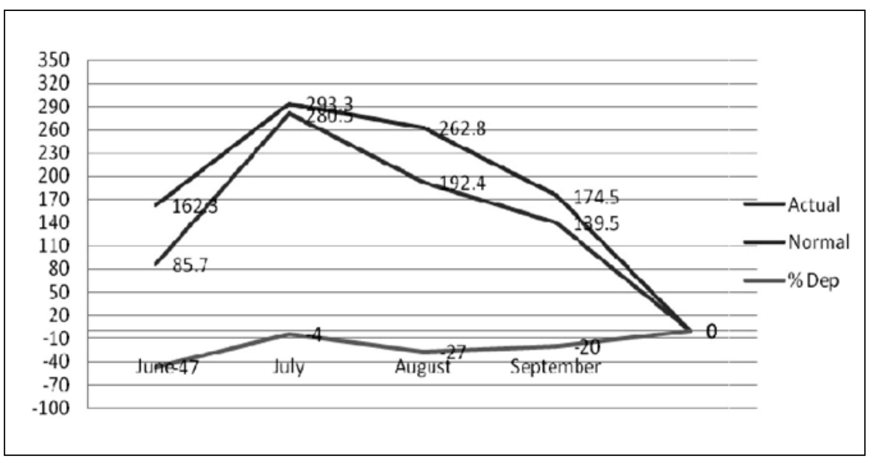
During the SW Monsoon 2009, except for four weeks, two in July and two in September, all other weeks registered deficit rainfall as is evident from the bar-diagram on weekly rainfall below:

***Graph-1**: Week by Week Deviation in Rainfall during SW Monsoon 2009*



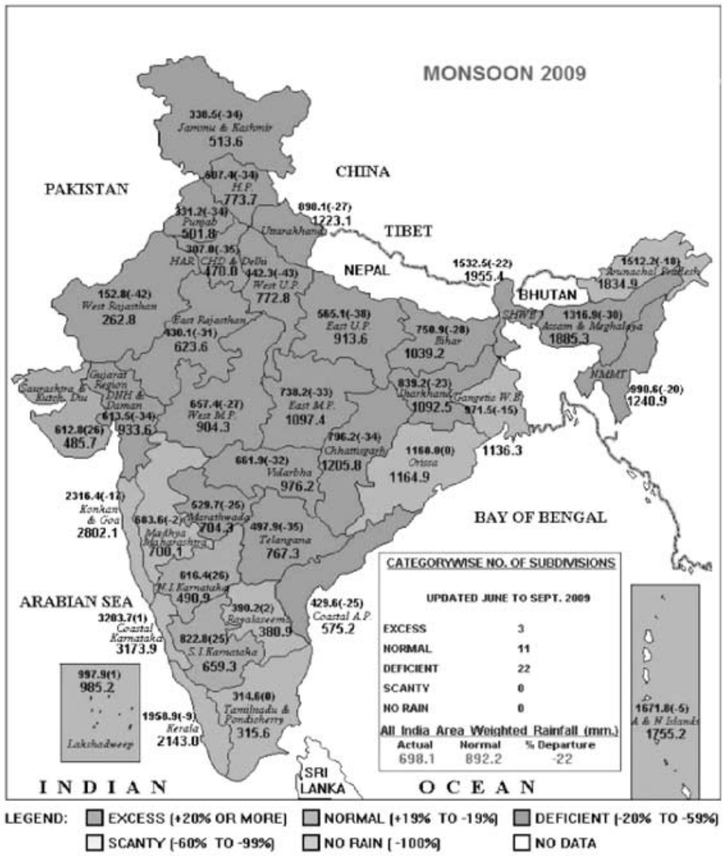
Graphical representation on the Normal rainfall during the season, Actual rainfall received and percentage deviation, month wise and during the season is given below:

***Graph – 2**: Rainfall during SW Monsoon 2009*



Meteorological sub-division wise rainfall in the country at the end of the South-West Monsoon season in 2009 is depicted in Map-2.

***Map - 2**: Meteorological Sub-Division wise Rainfall during South-West Monsoon 2009*

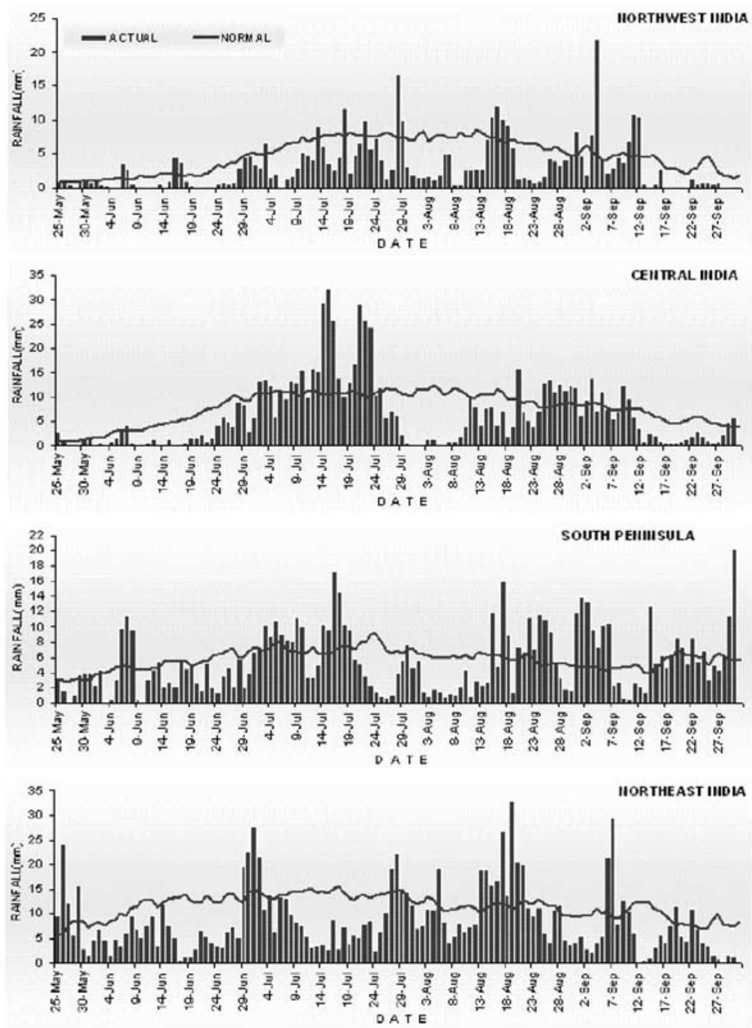


Notes:
(a) Rainfall figures are based on operational data
(b) Small figures indicate actual rainfall (mm), while bold figures indicate Normal rainfall (mm.)
Percentage Departures of Rainfall are shown in Brackets

***Sources** : IMD*

Weekly rainfall in the four zones of the country and the deviation from the normal during the whole of SW Monsoon is represented in Graph-3.

***Graph-3**: Weekly Rainfall Distribution in Four Regions*

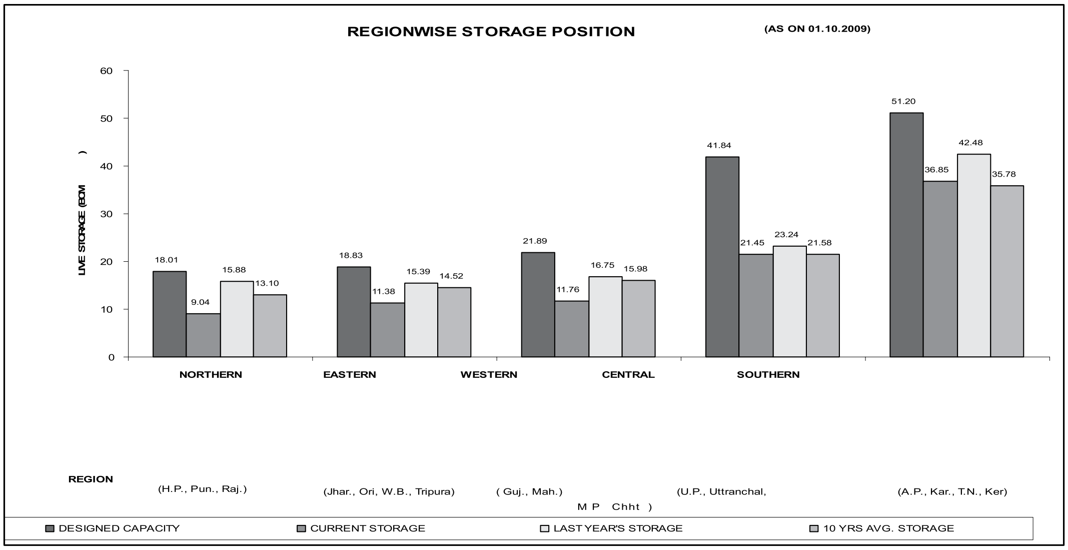


***Sources** : IMD*

Storage of water in major reservoirs

Water storage in 81 important reservoirs in the country is monitored by the Government through the Central Water Commission (CWC). Water storage during 2009 in these reservoirs was nearly 80 percent of the previous year's (2008-09) storage and 90 percent of the average of last ten years. The water level in these reservoirs was much lower, due to deficit rainfall during the South-West Monsoon, 2009. The reservoirs in northern India particularly had low water storage. A graphical representation of region wise water storage position in the reservoirs of the country is depicted in the bar diagram below:

***Graph-4**: Water Storage in 81 Important Reservoirs at the End of South-West Monsoon 2009*

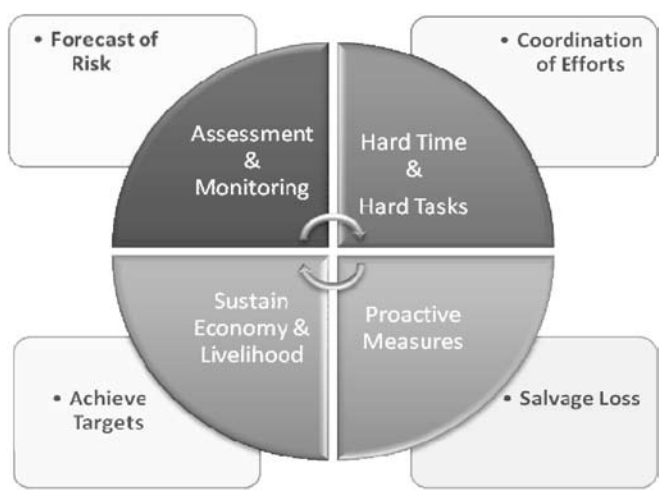


Mitigation strategy

Drought 2009 was the worst drought experienced in the country in the past 37 years. 338 Districts in 14 States of Andhra Pradesh, Assam, Bihar, Himachal Pradesh, Jammu & Kashmir, Jharkhand, Karnataka, Madhya Pradesh, Maharashtra, Manipur, Nagaland, Orissa, Rajasthan and Uttar Pradesh have been declared as drought affected. Around 120.53 million human population and 48 million animal population got affected by drought. About 30 million hectares of cropped area were damaged. Another state, Kerala declared drought in 14 districts on 19.3.2010 owing to acute shortage of drinking water and drying up of water sources.

Drought is a long drawn calamity as it takes a long time to set in. The indicators of impending drought are available early. To mitigate the impact of drought during 2009, these indicators were monitored closely from the very beginning of the monsoon season in order to assess the intensity or severity of the calamity. Based on such assessment a reasonable anticipation of the impending difficult situation was made. Once an assessment was made, the next stage was to pool scarce resources and gear up the administrative machinery towards taking pro-active measures, to salvage the losses and sustain the economy and livelihood of the affected population. A diagrammatic representation of the approach for managing drought in 2009 is given below.

Approach to management of drought 2009



Reacting to Early Signals

Though India Meteorological Department (IMD) had predicted a near normal monsoon for 2009 in its long term assessment, early signals of erratic monsoon were available from the onset of monsoon, based on which the States were immediately alerted. This helped in gearing up of the administrative machinery towards the impending crisis.

Monitoring and Coordination

As a strategy, all the Ministries and Departments of the Central and State Governments responsible for monitoring and taking action in mitigating the impact of drought along with the Organizations / Agencies under them, were involved in the exercise of drought management.

Scientific and research institutions in the country such as Indian Meteorological Department (IMD), Indian Council for Agricultural Research (ICAR), National Remote Sensing Centre (NRSC), Central Research Institute for Dryland Agriculture (CRIDA), Central Arid Zone Research Institute (CAZRI), Indian Grassland & Fodder Research Institute (IG&FRI) and State Agriculture Universities were involved in collating information to draw up mitigation strategy.

Review meetings were taken with the Agriculture Secretaries and Relief Commissioners of the States separately to firm up strategy on the agriculture and relief front. Through video Conferences, telephonic calls and exchange of e-mails, a constant review was taken as often as required to assess the situation at the ground level, especially regarding availability of agricultural inputs (like seed, fertilizer, etc.) for additional area coverage/alternate crops, water, power, fodder, drinking water, medicines and funds. A Control Room was functioning at DAC to constantly monitor the situation with the States. Similarly, the affected States also opened Control Rooms to monitor the situation and they were in touch with the district level Control Rooms.

The Prime Minister addressed the Chief Ministers and the Union Agriculture Minister followed up with a Conference of Agriculture and Food Ministers of the States to review the position on drought and to emphasize the action required to be taken. Arising out of deliberations in these conferences, a strategy was framed and shared with the states to cope with the crisis situation. In the States, the Chief Ministers reviewed the position periodically. Agriculture Minister wrote to his Cabinet Colleagues and all the Members of Parliament seeking their cooperation in taking steps for drought proofing and other related activities to mitigate the impact of drought.

An Inter-Ministerial Group under the Chairmanship of Secretary (Agriculture & Cooperation) with Secretaries of 19 Other Ministries / Departments was formed to assess the situation and take appropriate action. The Group met as often as required to combat the crisis. The Cabinet Secretary reviewed the situation from time to time. The State Governments set up review committees under the chairmanship of the Chief Secretary, which met as often as required to review the situation for taking appropriate remedial action.

Officials and Consultants engaged with the National Rainfed Area Authority and the Department of Agriculture and Cooperation were deputed to the drought affected areas to make on the spot assessment and provide technical advice/support to the State Government functionaries and farmers to overcome the situation.

Resource Mobilisation

It is primarily the responsibility of the State Governments concerned for taking necessary measures in the wake of natural calamities including drought, for which they have ready availability of funds under the Calamity Relief Fund (CRF). The Government of India supplements the efforts of the States with logistic and other supports. Additional financial assistance, over and above CRF, is considered from the National Calamity Relief Fund (NCCF) for natural calamities of severe nature in accordance with an established procedure of submission of Memorandum seeking Central assistance by the affected State. There are laid down items and norms for incurring expenditure out of these relief funds. In accordance with the recommendations of the 13th Finance Commission, CRF and NCCF have been substituted by the State Disaster Relief Fund (SDRF) and the National Disaster Relief Fund (NDRF), respectively, from 1.4.2010 on similar pattern of assistance.

Inter-Ministerial Central Teams (IMCTs) were deputed to all the 15 drought affected States for assessment of the situation and requirement of Central assistance. Taking into account the recommendations of the Inter-Ministerial Central Teams (IMCTs) and keeping in view the items and norms, Government of India approved assistance from NCCF, subject to adjustment of available balance in the CRF of the respective States. An amount of Rs. 2554.8765 crores (1200.79 billion $) as Central Share from the Calamity Relief Fund (CRF) was released to the admissible drought affected States. An amount of Rs. 4957.665crores (2330.10 billion $) was approved from the National Calamity Contingency Fund for drought relief to 13 States. The proposals of two states are under consideration.

The Government also approved a special package of Rs.800 crores for Punjab and Rs.400 crores for Haryana for taking necessary measures to mitigate the impact of drought on standing crops.

Credit

Considering the fact that drought is going to impact agricultural sector, the Reserve Bank of India issued guidelines on 1st July, 2009 to the banks for providing relief to the farmers in areas affected by natural calamities. These guidelines were meant to enable the banks to take uniform and concerted action expeditiously, particularly to provide financial assistance to the farmers affected by natural calamities. Loans were re-scheduled and short-term loans were converted into long-term loans. The time limit for repayment of dues was also extended. Due to these pro-active measures of the Government, the total agriculture credit flow was higher than the credit flow for the same period during 2008-09.

Containing Agricultural Production Loss

A two pronged strategy was worked out to tackle the impact of drought on agricultural production:

- Save the kharif standing crops and guide the farmers to go in for alternate crops requiring less water;
- Prepare for early Rabi to maximize coverage for higher production;

To operationalize this strategy, funds under the Centrally Sponsored Schemes like Rashtriya Krishi Vikas Yojana (RKVY), National Food security Mission (NFSM), National Horticultural Mission (NHM) were released to the States quite early so that they have ready availability of funds to take appropriate agricultural reconstructive measures. Flexibility was provided to the States to utilise these funds to meet the contingent situation.

Further, the Government introduced a new "Diesel Subsidy Scheme" during Kharif 2009 for providing supplementary irrigation by using diesel pump sets for saving the standing crops in the field to mitigate the adverse impact of drought/deficit rainfall conditions on food grains production. The scheme was intended to share the financial burden of the farmers affected by drought in providing protective irrigations to the standing crops by providing 50% subsidy on the cost of diesel. The burden of providing diesel subsidy to the farmers was shared in the ratio of 50:50 between the Government of India and the implementing States.

The Government also took a decision to release additional power to the States with deficit rainfall for agricultural operations during the months of July and August, 2009.

Additional seed was made available to the affected farmers as they had lost their seeds due to drought. The rate of existing subsidy on seed was enhanced for rice, wheat, coarse cereals, pulses and oilseeds to help the farmers severely affected by the failure of South West monsoon during the Kharif season. Expeditious transfer of seed was coordinated from surplus to deficit areas as per the requirement. Seed minikits were also provided under schemes like NFSM and Integrated Scheme of Oilseeds, Pulses, Maize and Oil palm (ISOPOM). Participatory seed production was substantially expanded through increased financial assistance under Seed Village programme. To increase fodder production for sustaining livestock, additional minikits were allocated to the States for free distribution to the farmers. Distribution of seed was closely monitored to effect timely sowing during Rabi.

Ensuring Livelihood

Towards ensuring a minimum level of livelihood and income security in the rural areas, a demand-driven statutory Mahatma Gandhi National Rural Employment Guarantee Scheme (MGNREGS) is in vogue in the country. The Scheme provides for 100 days of guaranteed wage employment in a financial year to every household whose adult members volunteer to do unskilled manual work. Under drought like conditions, rural labour becomes jobless due to fall in agricultural activity and this Scheme comes handy as it guarantees wage employment to them under such conditions.

This Scheme was very effective in mitigating the impact of drought on livelihood generation during 2009. The shortfall in employment due to fall in agricultural activities was compensated by providing employment under the Scheme. Further, for districts, which crossed the limit of 100 days under MGNREGS, the Government made special dispensation to provide additional 50 days of employment from CRF/ NCCF, over and above the existing 100 days of employment. Out of 46.03 lakh number of works undertaken during this period under MGNREGS, 10.95 lakh number of works were undertaken for water conservation and water harvesting, 3.60 lakh number of works were undertaken for drought proofing, 2.98 lakh number of works for micro irrigation, 7.77 lakh number of works were undertaken for irrigation facility on private land holding and 3.96 lakh number of works for renovation of traditional water bodies. This emphasizes that the Scheme not only addressed the problem of wage employment under drought conditions but also addressed the current and future drought risks through creation of water sources.

Under the Centrally Sponsored Scheme namely "National Rural Drinking Water Supply Programme (NRDWP)" technical and financial assistance was provided to the States to mitigate possible scarcity of drinking water. In view of the drought situation and need to go for additional crop area during the Rabi season, consultation with the State Governments was pre-poned and Action Plan was worked out in advance, the plan for procurement of fertilizers and pre-position them in all the States where prospects of Rabi crop were good.

The State Governments, while formulating the RKVY Action Plan, were advised to take into consideration the situation arising out of delayed monsoon and efforts required to be made as per the Contingency Plan and factor them into the Action Plan under RKVY. Funds under the Centrally Sponsored Schemes are normally released on the basis of utilization by the States by adjusting the unspent balance pending with them. To mitigate the prevailing drought situation in the country in 2009-10, the Government decided to release 100% funds under Rashtriya Krishi Vikas Yojana (RKVY) to the States / UTs. During the financial year 2009-10, Rs. 1069.39 crores (502.61billion $) under NFSM, Rs. 3756.48 crores (1765.54billion $) under RKVY and Rs.800.15 crores (376.07billion $) under NHM were released to enable the States to take appropriate agriculture re-construction measures.

As a consequence of such pro-active preventive measures taken to mitigate the impact of drought, food grain production was salvaged and is estimated to be 218.2 million tonnes during 2009-10. This is significantly higher than the food grain production of 174.07 million tonnes during the previous drought year of 2002-03.

Drought risk management in agriculture in india

The major problem confronting the rural areas in general and farm households in particular is low productivity of Indian agriculture and lack of employment opportunities to supplement the farm income. Efforts are needed to strengthen the farm sector through increased investment in developing quality agricultural inputs, irrigation, watershed development, wasteland development, land reclamation, etc to strengthen agriculture and increase productivity to withstand the impact of climatic variation. In addition, there has to be a greater focus on the accelerated development of the rural non-farm sector to offset the fluctuations of the farm sector. A growing farm sector supported by better rural infrastructure and connectivity, adequate power supply, easy availability of credit and skilled workers, help in creation of more employment opportunities in the rural non-farm sector, which in turn enhances the income of farm households. This helps the rural population in withstanding the adverse effects of natural calamities, including drought.

Despite technological and economic advancements, the condition of agricultural sector continues to be risky. In order to reduce risk and impart greater resilience to Indian agriculture against natural calamities including droughts, efforts are required for protecting the farm sector from the vagaries of nature. Towards this objective, agriculture contingency planning, development of drought and flood resistant crop varieties, watershed development programme, drought prone areas and desert development programme and rural infrastructure development programme have received added attention in the Country over the past decades. New schemes like Rashtriya Krishi Vikas Yojana (National Agriculture Development Plan), Mahatama Gandhi National Rural

Employment Guarantee Scheme, National Mission on Micro Irrigation, Prime Minister's Gramin Rojgar Yojana (Prime Minister's Village Employment Plan), Backward Region Growth Fund, etc., are being implemented in the country to achieve the aforesaid objective.

Government of India also ensures remunerative prices through the mechanism of Minimum Support Price (MSP) policy for major agricultural commodities. The price structure and trade mechanism is continuously reviewed to ensure a favourable economic environment for the agriculture sector and to bring about an equitable balance between the rural and the urban incomes. The price structure of both inputs and outputs is monitored to ensure higher returns to the farmers and bring about cost effectiveness in the economy. Domestic market prices are also closely monitored to prevent distress sales by the farmers and also appropriate market intervention measures are unveiled to insulate the consumers from rising prices. Public and cooperative agencies undertaking marketing operations are being strengthened. The Government has enlarged the coverage of futures markets to minimize the wide fluctuations in commodity prices as also for hedging their risks.

Disaster risk reduction: strategies and practices

Climate-related stresses and shocks are already figuring prominently in the lives of people in the world and particularly so in case of the poor. Events such as droughts, floods and cyclones and earthquakes are often terrible experiences for those affected. They cause insurmountable pain and suffering through loss of life, destruction of livelihood opportunities and property.

In the coming times, climate change is expected to exacerbate the risks of disasters, not only from more frequent and intense hazard events but also through greater vulnerability due to increase in population. Many of the countries that have populations vulnerable to natural disasters now, will face even greater risk owing to the impact of climate change. More frequent and intense storms and floods, long-lasting droughts erode the existing capacity of the community to prepare, respond and rebuild after successive hazard events. Other adverse impacts of climate change, for example on public health, ecosystems and food security, will further increase the vulnerability of communities, especially of the vulnerable groups such as children, the elderly and women to natural hazards of all types. Any increase in disaster, whether large or small, will threaten developmental gains and hinder the implementation of the Millennium Development Goals (MDGs).

To move forward from the relief based post disaster response to pre-disaster risk reduction management approach, there is a need for setting up of an "integrated and continuous mechanism" for monitoring and managing the calamity and this also holds true for drought risk management. This would make a wide impact; develop and enhance the capacity for real time monitoring for early warning, decision support system for timely response, identification and implementation of appropriate mitigation measures, capacity building of policy makers, implementers, drought risk managers and public. There is also a requirement for integrating with easy to use existing village level dynamic drought mitigation models that would ensure fater acceptability for minimizing the serious effects of drought.

There is a need for exchange of ideas to adopt best practices in risk reduction management in drought. The investment in risk reduction and mitigation measures also has to be propagated after a detailed cost-benefit analysis. Better cohesiveness has to be brought in the use of prediction tools and the models being adopted to narrow the gap between the outcome of risk management exercise and the actual impact of climate change. Weather forecasting has to be reduced to micro scale on near real time sub-district level to be more effective for undertaking mitigating exercises. Also the gap existing in policy planning, implementation of programme and the development of institutional systems has to be resolved to effect meaningful mitigating impact.

While the current focus is on more effective and enhanced preparedness for drought risk management, there is need for looking at agricultural and livelihood security in equal measure for sustainable management of ecological and natural resources, especially with focus on rural areas. This could lead to a reduction in drought related devastations.

Conclusion

Triggered by devastating disasters that happened in South Asia during the last decade or so, there is now an increased awareness in the region on the need to have a coordinated prevention and mitigation strategy to face disasters instead for waiting it to happen. Although management of disaster has moved forward from post disaster response to pre-disaster preparedness, it is still being implemented in isolation. Despite increase in frequency and impact of disasters, majority of the developmental programme do not usually incorporate disaster risk reduction measures, whether they are being implemented by the government or NGOs,. These gaps are gradually being realized and addressed. While some countries and institutions are working on this, there is need to institutionalise this.

There are best practices found in the region, which highlight experiences of organisations focused on different aspects of Disaster Risk Reduction using their own expertise and areas of concentration in achieving the desired outcome. For the benefit of the mankind these experiences need to be documented and shared. Managing Drought in 2009 in India is one such experience.

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- Geography of India – www.india.gov.in

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Monitoring and Early Warning of Drought in India

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Introduction

The economy of India is greatly dependent on water resources as well as rainfall. The erratic nature of monsoon rainfall gives rise to low rainfall in some years leading to drought and normal to excess rainfall in others. Drought, which may lead to famine, is indeed one of the worst environmental hazards because its onset is slow; the affected area is quite widespread; and the adverse impacts are ruinous. Drought imparts a creeping long term setbacks to the socio-economic fabric of the society which has the misfortune to be visited by it (Kulshrestha, 1997). During the 30-year period 1963-1992 though the number of deaths directly attributable to drought is quite less (3%) compared to that caused by floods (26%) and tropical cyclones (19%), yet the number of persons affected by drought (33%) is the highest amongst all the natural disasters (number of persons affected by floods and tropical cyclones being 32% and 20% respectively) and the significant damage caused by drought is 22% which is comparable to the corresponding values of floods (32%) and tropical cyclones (30%) (WMO,1994). India gets nearly 80% of its annual rainfall during the southwest monsoon season (June to September). Delayed onset of monsoon, prolonged breaks in the monsoon during the normally most active months of July and August, early withdrawal of monsoon and erratic distribution of rainfall during monsoon season – make our country, especially the low rainfall belts, vulnerable to droughts.

For proper monitoring and assessment of droughts different drought indices are used. India Meteorological Department (IMD) monitors meteorological and agricultural drought based on 'percentage of rainfall departure' and 'aridity anomaly index' respectively, whereas the National Remote Sensing center (NRSC), Hyderabad monitors agricultural drought using remote sensing technique.

Drought monitoring in india

A well established drought monitoring system exists in India. India Meteorological Department (IMD) and National Remote Sensing Centre (NRSC), Hyderabad have been monitoring drought over the country by the conventional way of rainfall monitoring and remote sensing methods respectively.

IMD monitors both the meteorological drought and agricultural droughts. Meteorological drought over an area is defined as a situation when the monsoon seasonal (June-September) rainfall over the area is less than 75% of its long-term average value. It is further classified as 'moderate drought. if the rainfall deficit is 26-50% and 'severe drought' when the deficit exceeds 50% of the normal.

Further, a year is considered as a 'drought year' when the area affected by moderate and severe drought either individually or together is 20-40% of the total area of the country and seasonal rainfall deficiency during southwest monsoon season for the country as a whole is atleast 10% or more. When the spatial coverage of drought is more than 40% then it is called as all India severe drought year (www.imd.gov.in).

Based on the index of percentage departure of rainfall from normal IMD has delineated sub-divisionwise drought since 1875. The droughts over a period of 135 years (1875-2009) have been identified and classified so far. Further, the drought prone areas have been identified and probabilities of moderate and severe drought occurrences have also been computed sub-divisionwise over the country (Table-1).

***Table - 1**: Sub-divisionwise frequencies of Moderate and Severe drought during 1875-2009 and probabilities of drought years*

S. N.	Name of Sub-division	Moderate	Severe	Total	Drought probabilities (Total) %
1.	Andaman & Nicobar Islands	17	0	17	13
2.	Arunachal Pradsh	7	1	8	6
3.	Assam & Meghalaya	5	0	5	4
4.	Nagaland, Manipur, Mizoram & Tripura	12	0	12	9
5.	Sub-Himalayan West Bengal	7	0	7	5
6.	Gangetic West Bengal	2	0	2	1
7.	Orissa	5	0	5	4
8.	Bihar	12	0	12	9
9.	Jharkhand	6	0	6	4
10.	East Uttar Pradesh	13	1	14	10
11.	West Uttar Pradesh	13	1	14	10
12.	Uttarakhand	16	2	18	13
13.	Haryana, Delhi & Chandigarh	21	4	25	19
14.	Punjab	20	4	24	18
15.	Himachal Pradesh	20	3	23	17
16.	Jammu & Kashmir	21	6	27	20
17.	West Rajasthan	22	12	34	25
18.	East Rajasthan	18	5	23	17
19.	West Madhya Pradesh	14	0	14	10
20	East Madhya Pradesh (including Chhattisgarh)	12	0	12	9
21.	Gujarat Region	17	11	28	21
22.	Saurashtra & Kutch	16	15	31	23
23.	Konkan & Goa	9	0	9	7
24.	Madhya Maharashtra	7	2	9	7
25.	Marathwada	17	1	18	13
26.	Vidarbha	16	1	17	13
27.	Coastal Andhra Pradesh	13	0	13	10
28.	Telangana	18	0	18	13
29.	Rayalaseema	20	2	22	16
30.	Tamil Nadu & Pondicherry	12	0	12	9
31.	Coastal Karnataka	5	0	5	4
32.	North Interior Karnataka	10	0	10	7
33.	South Interior Karnataka	9	0	9	7
34.	Kerala	10	0	10	7
35.	Lakshdweep	10	3	13	10

Data in the above table reveals that arid west viz. West Rajasthan (34 cases) and Saurashtra and Kutch (31 cases), have the highest occurrences of drought. The adjoining Gujarat Region which mostly belongs to semi-arid climate also experiences high incidences of drought (28). Other areas recording large incidences of drought are Haryana, Delhi & Chandigarh, Punjab, Himachal Pradesh and East Rajasthan in northwest India and Rayalaseema in southern peninsula. The per-humid and humid areas of the east and north-east India (viz. Arunachal Pradesh, Assam& Meghalaya, Orissa, Gangetic West Bengal and Jharkhand), for obvious reasons, have the lowest occurrences of drought.

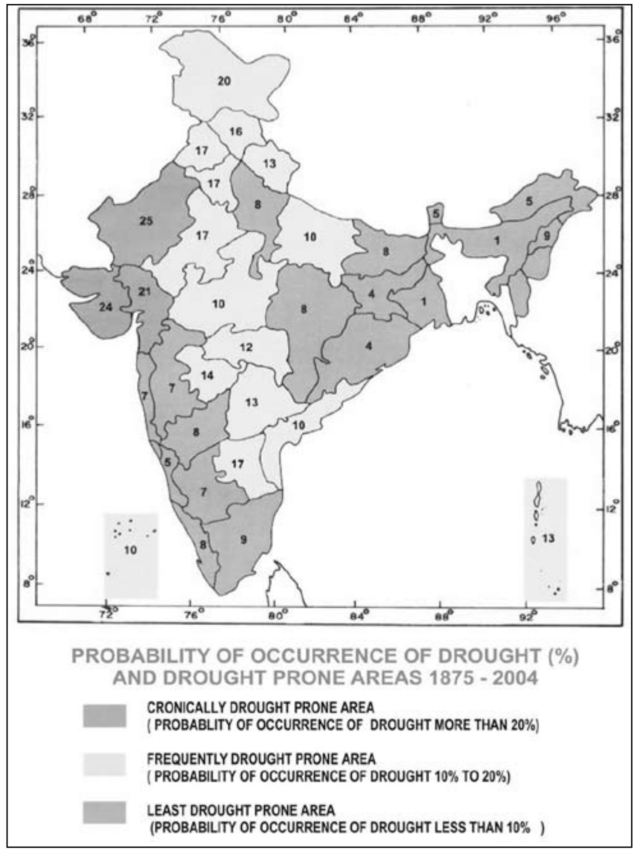

Figure 1

Based on the probabilities of occurrence of drought (percentage) the entire country has been divided (Figure I) into chronically drought prone area (probability of occurrence of drought more than 20%), frequently drought prone area (probability of occurrence of drought 10-20%) and least drought prone area (probability of occurrence of drought less than 10%) (IMD Met. Monograph no. 21/2005).

The Figure1 reveals that West Rajasthan and the entire Gujarat State fall in the category of chronically drought prone area. Therefore, these area deserve special attention for drought proofing like evolving crop varieties resistant to moisture stress, better water management, effective land management etc. East Uttar Pradesh, Uttarakhand, Haryana, Punjab, Himachal Pradesh, East Rajasthan, West Madhya Pradesh, Marathwada, Vidarbha, Telangana, Coastal Andhra Pradesh and Rayalaseema fell in the category of frequently drought prone areas which can expect drought once in 6-10 years. These areas generally belong to sub-humid climate zone (IMD Met. Monograph No. 21/2005).

Further districtwise moderate and severe drought probabilities using long term rainfall data have also been worked out and presented in Figures2 and 3 respectively. (NCC 12).

Figures 2 shows that in most parts of India, the probabilities of moderate drought are in the range of 11-20%. However, moderate drought probabilities of more than 21% are observed in northwest region of India and some parts of westcentral India and peninsular region.

From Figure3 it has been observed that the major parts of India show probability of severe drought in the range of 1-5%. In some parts of northwest region, northern hilly region and peninsular region probability of

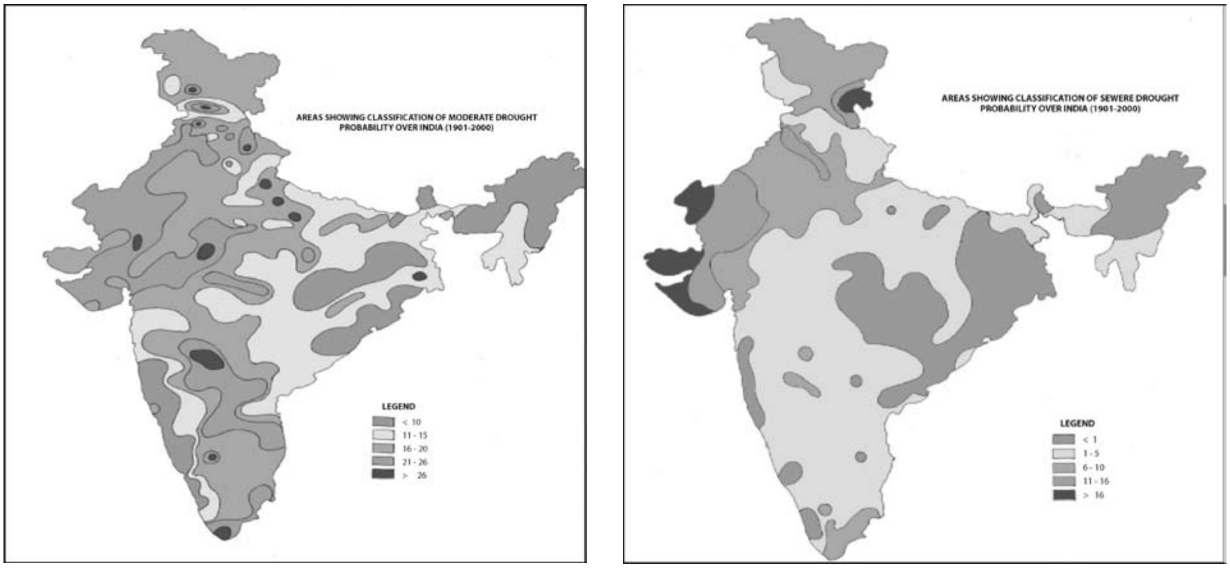

Figure 2 & 3

severe drought is in the range of 6-10%. However, In extreme northwest region, especially in the region of Saurashtra & Kutch it is greater than 20%(NCC Research Report 12, 2010).

Index based on SPI

Although rainfall deviation from the long-term mean continues to be a widely adopted indicator for drought intensity assessment because of its simplicity, yet its application is strongly limited by its inherent nature of dependence on mean. Rainfall deviations cannot be applied uniformly to different areas having different amounts of mean rainfall since a high and a low rainfall area can have the same rainfall deviation for two different amounts of actual rainfall. Therefore, rainfall deviations across space and time need to be interpreted with utmost care (Naresh Kumar et al, 2009).

SPI expresses the actual rainfall as standardized departure from rainfall probability distribution function and, hence, this index has gained importance in recent years as a potential drought indicator permitting comparisons across space and time (Naresh Kumar et al, 2009).

Keeping this in mind, a weekly drought monitoring scheme, based on Standardized Precipitation Index (SPI), is being by developed IMD for operational monitoring of drought over India. Earlier there were some studies (Hughes and Saunders, 2002, Hayes et al. 1999, Mihajlovic, 2006) developing SPI-based drought monitoring scheme on a monthly time scale. However, it was strongly felt (Hayes et al. 1999) that developing a SPI-based drought monitoring scheme on a weekly/biweekly time scale would further improve the usefulness of SPI in drought monitoring. Computation of SPI involved fitting a gamma probability density function to a given frequency distribution of precipitation totals for a station. The alpha and beta, shape and scale parameters respectively, of the gamma distribution were estimated for each station for a timescale of week for each year. Alpha and beta parameters were then used to find the cumulative probability of an observed precipitation amount, which was then transformed into the standardized normal distribution. Thus, SPI could be said to be normalized in space and time scale. SPI as a drought index is very versatile as it can be calculated on any timescale, so suitable for agricultural and hydrological applications. This versatility is also critical for monitoring the temporal dynamics of a drought, including its development and decline. These aspects of a drought have always been difficult to track with other indices; further, as SPI values are normally distributed, the frequencies of extreme and severe drought events for any location and timescale are consistent.

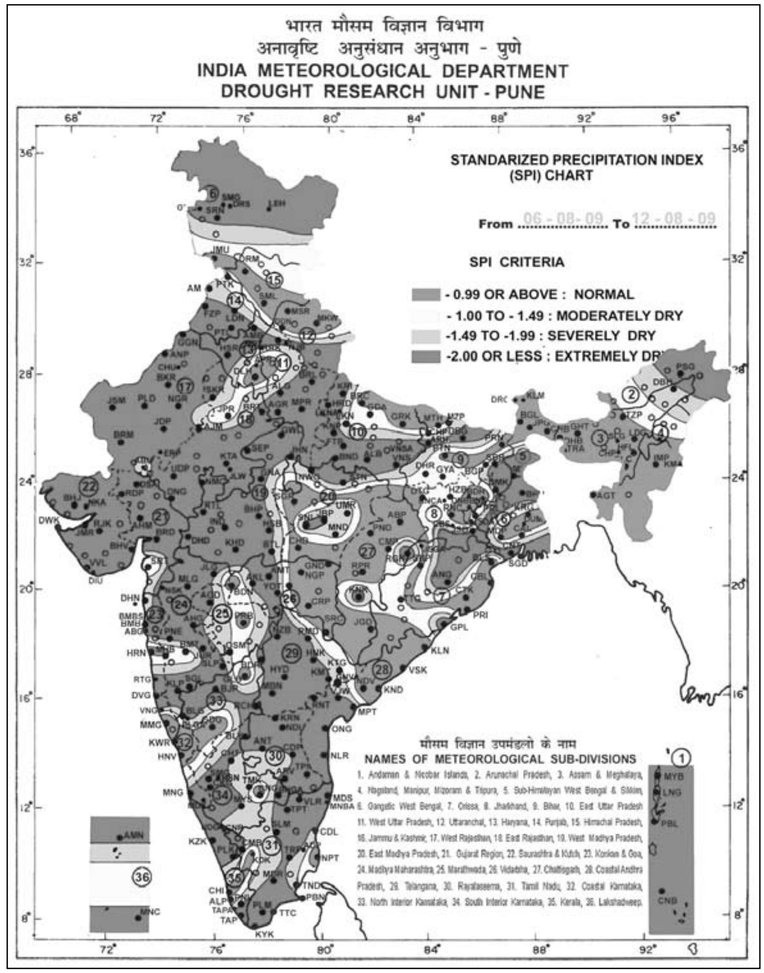

Figure 4

SPI, when used for monitoring drought on a weekly time scale for the monsoon-2009, found to portray a realistic picture of drought scenario over the country (Figure 4).Further, an attempt has also been made to analyze drought (Table – 2) over India based on SPI. Main objective was to see how effective SPI was in diagnosing drought intensity over a longer period of time. Rainfall data ((All India Seasonal rainfall (June – September)) used for the study was from 1875 to 2009. The analysis revealed that out of 135 years (1875 – 2009) SPI diagnosed five years – 1877, 1899, 1918, 1972 and 2009 as All India extreme drought years when SPI value exceeded -2.0.This result was in agreement with the analysis of Mooley (1994) who while analyzing data from 1871 to 1996 found that in the years of 1877, 1899, 1918, 1972 and 1987 Phenomenal All India droughts affected our country. Mooley(1994) defined Phenomenal All India drought as a phenomenon when % departure of monsoon season's rainfall was $\leq$ -2 SD i.e. -20% and the percentage area under deficient monsoon rainfall was equal to or more than mean+2SD i.e. 47.7%. Therefore, Phenomenal drought years identified by Mooley(1994) has been effectively diagnosed as extreme drought years by the SPI. Further, SPI was also able to diagnose properly the other All India moderate/severe drought years that affected our country.

However, it may be mentioned that despite the current optimism about the SPI, it cannot solve all moisture monitoring concerns. Rather, for a shorter time scale (week/ fortnight),it can be considered as a tool that can be used in coordination with other tools, such as the PDSI (Palmer Drought Severity Index), aridity anomaly index or remote sensing data, to detect the development of droughts and monitor their intensity and duration. This will further improve the timely identification of emerging drought conditions that can trigger appropriate responses by the policy makers.

Index based on aridity anomaly

For monitoring cessation, incidence, spread and intensification of agricultural drought an index called Aridity Anomaly Index is used which is given as follows:

$$AI = \frac{PE - AE}{PE} \times 100$$

AE = Actual evapotranspiration, computed by Thornthwaite's water balance technique (Thornthwaite and Mather,1957) using actual rainfall and FC.

Actual AI (AAI) values are computed stationwise. Similarly, stationwise normal AI (NAI) values are also computed using normal rainfall values. Differences between NAI and AAI called 'Anomaly of Aridity Index', are used to categorize agricultural drought as per the following criteria:

Anomaly of Aridity Index	Agricultural Drought Intensity
1 – 25	Mild
26 – 50	Moderate
>50	Severe

***Table – 2** : Drought Intensity over India based on Standardized Precipitation Index (SPI)*

DroughtYear	Seasonal (Jun –Sept.) Rainfall (cm0	SPI value	Drought intensity as per SPI value
1877	58.7	-3.47	ED
1899	62.1	-3.01	ED
1901	76.5	-1.21	MD
1904	77.6	-1.08	MD
1905	72.7	-1.66	SD
1911	75.1	-1.38	MD
1918	66.1	-2.48	ED
1920	73.3	-1.59	SD
1941	76.3	-1.23	MD
1951	71.5	-1.81	SD
1965	72.0	-1.75	SD
1966	76.4	-1.22	MD
1972	67.0	-2.37	ED
1974	77.4	-1.11	MD
1979	71.4	-1.82	SD
1982	75.2	-1.36	MD
1986	76.8	1.18	MD
1987	70.9	-1.88	SD
2002	71.3	-1.83	SD
2004	76.6	-1.20	MD
2009	69.8	-2.02	ED

Based on this aridity index, weekly/fortnightly Aridity Anomaly Maps/ Reports for Southwest Monsoon Season for the whole country and for Northeast Monsoon Season for the five meteorological sub divisions, viz. coastal Andhra Pradesh, Rayalaseema, south Interior Karnataka, Tamil Nadu & Pondicherry and Kerala, are prepared and sent to various user communities in near real time basis for their use in Agricultural Planning and Research purposes. The aridity anomaly maps are also uploaded in the departmental website (www.imd.gov.in). This index helps to assess the moisture stress experienced by growing plants. A few aridity anomaly maps, pertaining to the drought year 2009, are presented in Figures 5 and 6.

Monitoring Drought by Remote Sensing Method

National Remote Sensing Agency (now NRSC), Hyderabad, Deptt. of Space, Govt. of India has been assessing and monitoring agricultural drought since 1989 under National Agricultural Drought Assessment and Monitoring Systems (NADAMS). Under NADAMS, agricultural conditions are monitored at district level using daily-observed coarse resolution (1.1 km) NOAA-AVHRR data for the entire country and at sub-district level using better spatial resolution IRS AWiFS/WiFS data .

Indian Remote Sensing Satellite(IRS) series (IRS 1C, IRS 1D and IRS P3) have WiFS (Wide field Sensor) payload which collects data in two spectral bands 0.62-0.68 um (red) and 0.77-0.86 um (near infrared) with spatial

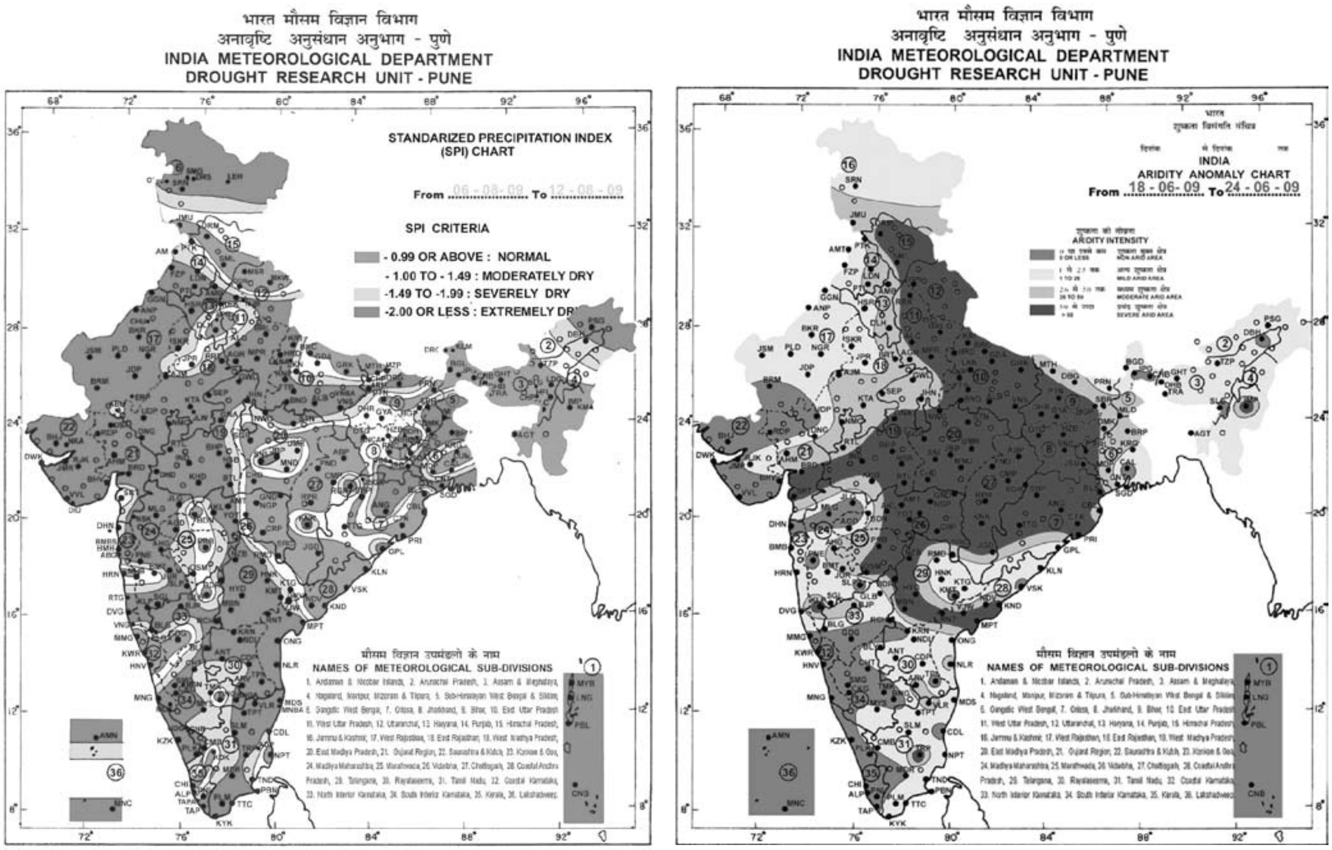

Figure 5 & 6

resolution of 188 m and ground swath of 810 km with a revisit period of 5 days. The IRS P6 (Resource Sat) has advanced WiFS (AWiFS) sensor that provide data with spectra, radiometric and spatial (56 metres) resolutions for better monitoring at agriculture. The combination of AWiFS/WiFS would be beneficial to increase the frequency of images with almost one coverage in two days time which is useful to minimize cloud contamination.

The crop/vegetation reflects high energy in the near infrared band due to its canopy geometry and health of the standing crops/vegetation and absorbs high in the red band due to its biomass and photosynthesis. Using these contrasting characteristics of vegetation in near infrared and ren bands, which indicate both the health and condition of the crops/vegetation; Normalised Difference Vegetation Index (NDVI) is derived by the difference of these measurements and divided by their sums. The vegetation index is generated from each of the available satellite data irrespective of the cloud cover present. To minimize the cloud, monthly time composite vegetation index is generated.

The monthly vegetation index map for the states with district boundaries overlaid are given in specific colors for the vegetation index ranges. The various colors in the NDVI map: yellow through green to violet indicate increasing green leaf area and biomass of different vegetation types. Cloud and water are represented in black and blue colors respectively. The bare soil, fallow and other non-vegetation categories are represented in brown colour.

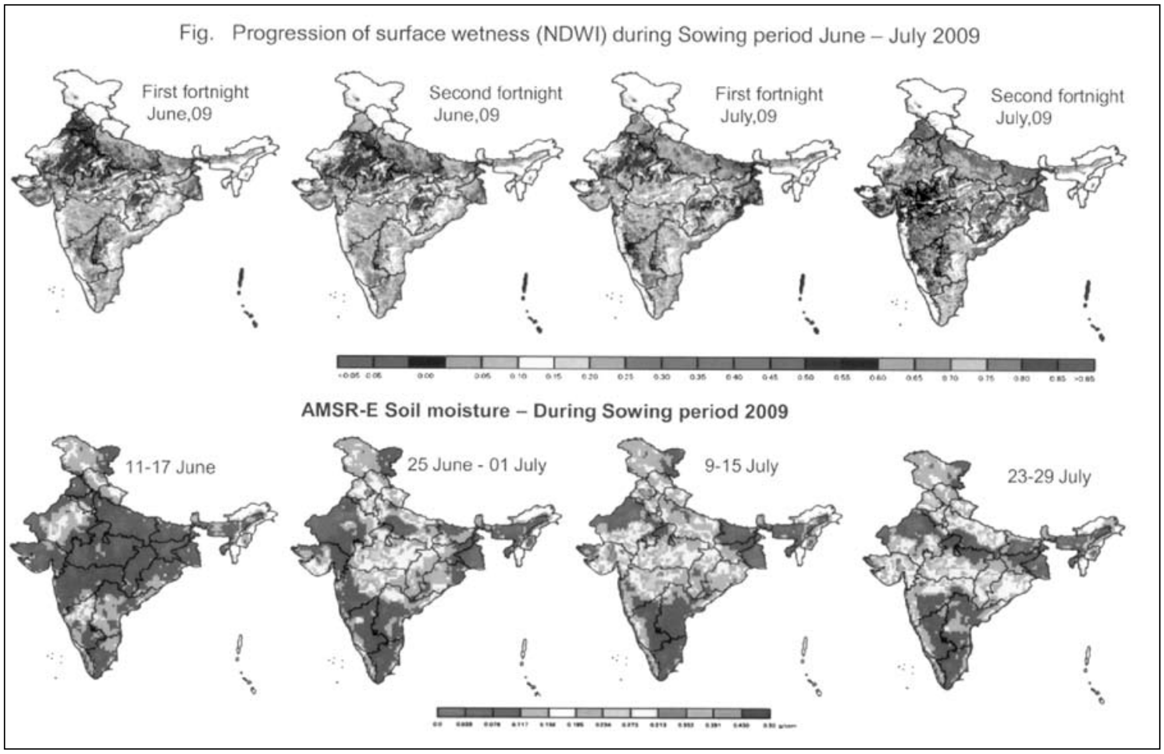
Fig. Progression of surface wetness (NDWI) during Sowing period June – July 2009
First fortnight June,09
Second fortnight June,09
First fortnight July,09
Second fortnight July,09
AMSR-E Soil moisture – During Sowing period 2009
11-17 June
25 June - 01 July
9-15 July
23-29 July

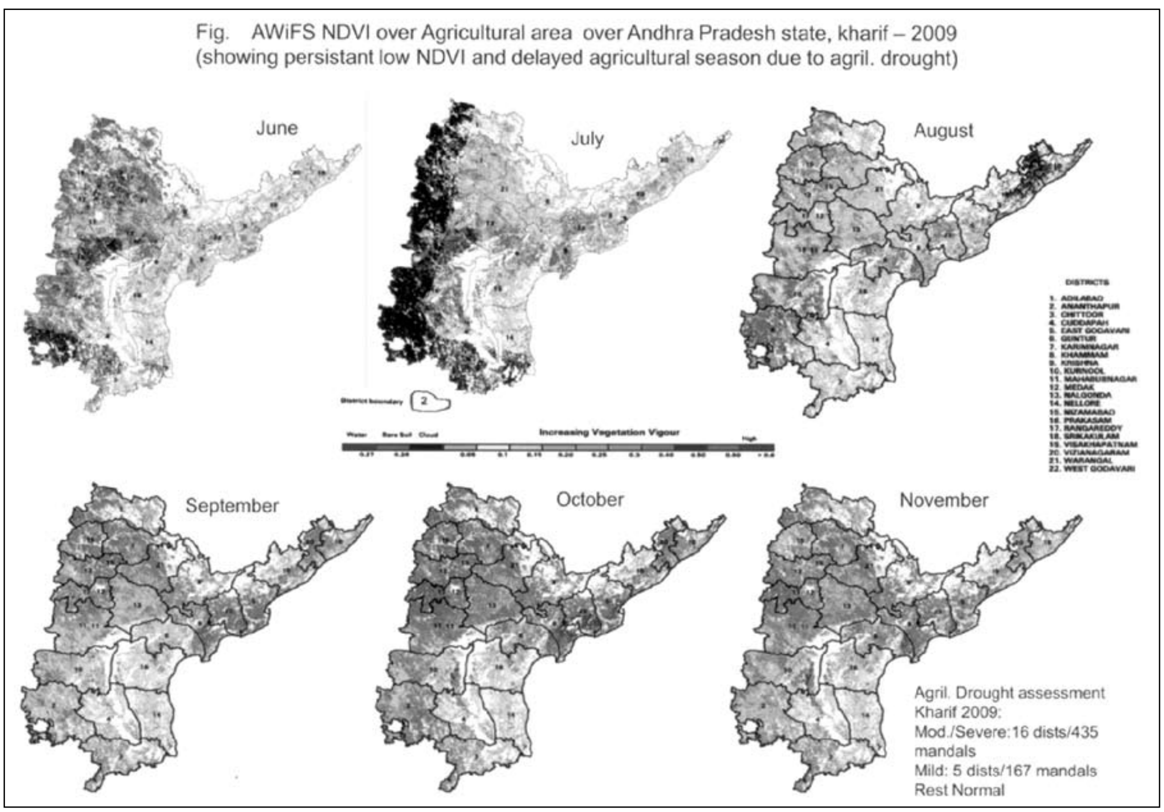
Fig. AWiFS NDVI over Agricultural area over Andhra Pradesh state, kharif – 2009
(showing persistant low NDVI and delayed agricultural season due to agril. drought)
June
July
August
DISTRICTS
Increasing Vegetation Vigour
September
October
November
Agril. Drought assessment
Kharif 2009:
Mod./Severe:16 dists/435 mandals
Mild: 5 dists/167 mandals
Rest Normal

Figure 7 & 8

The composite NDVI images are generated for each month of monsoon separately for the total geographic area and for the agricultural area of the state. The seasonal progression of NDVI compared to that of normal and complementary ground data on rainfall and crop sowing progress are utilized in the assessment of agricultural drought. Figs. 7 and 8 depict monitoring of agricultural drought by remote sensing method during the monsoom season of 2009 (NRSC Drought Report, 2009).

Drought Prediction Scenario

The most important and difficult aspect is the prediction of drought with reasonable accuracy and sufficiently well in advance. For this, it is necessary to predict with a reasonable degree of success the years of poor monsoon rainfall, which may lead to drought. As of now, India Meteorological Department follows a two-stage forecast strategy for long range forecasting of the south-west monsoon rainfall over the country as a whole. The first long range forecast for the south-west monsoon season (June-September) rainfall is issued in April and the forecast update is issued in June. During the last two years (2007-2008), IMD has been using the following statistical models for forecasting the south-west monsoon rainfall (June-September) for the country as a whole:

- A 5-parameter statistical ensemble forecasting system requiring data up to March, for the first forecast in April.
- A 6-parameter statistical ensemble forecasting system requiring data up to May for the forecast update in June. The rainfall forecasts for four homogeneous regions and All India July and August are also generated.

Further, since 2009 IMD has started issuing Drought Outlook which, based on forecast rainfall, presents a scenario of drought conditions over our country one week ahead. Numerical weather prediction products like 'Probability of Below Normal Monthly Rainfall' (Figure9) one month in advance could be utilized for drought prediction purposes.

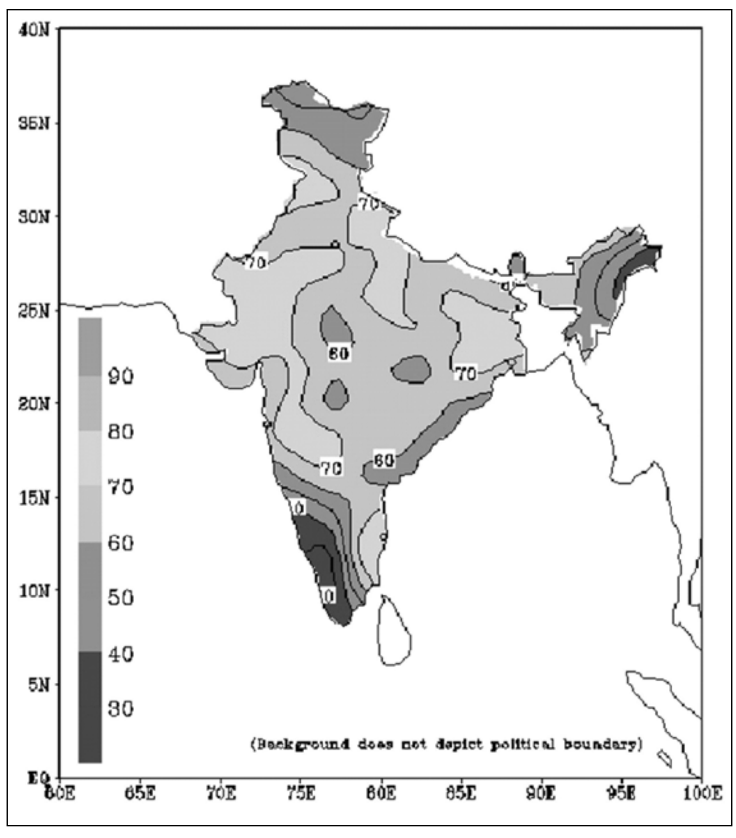

***Figure 9:** Probability of Below Normal Rainfall Valid for June, 2010 (www.imd.gov.in)*

Concluding remarks

- This paper has highlighted the drought indices which are currently in use for monitoring drought in India.
- Drought risks have been identified by delineating the country into chronically (probability of drought occurrence exceeds 20%), frequently (probability of drought occurrence 10% -20%) and least drought prone (probability of drought occurrence less than 10%) areas.

- For meteorological drought monitoring in India, percentage rainfall departure from normal is used as an index. SPI, being developed and tested, has also shown promise in monitoring meteorological drought.
- For monitoring and assessing agricultural drought aridity anomaly index is used in India. Besides, remote sensing applications by NRSC, India could also be very effective in assessing drought severity, their impacts on sectors like agriculture, and related policy decisions.
- India Meteorological Department provides future scenario of rainfall over the country as a whole on a seasonal scale (June- September) by statistical ensemble forecasting system. Besides, IMD generated product, like 'Probability of Below Normal monthly Rainfall', are very good inputs from the point of view of future drought scenario over the country.

Acknowledgement

The author is thankful to AVM Dr. Ajit Tyagi, Director General of Meteorology, India Meteorological Department for giving him the opportunity to present the paper in the SAARC WORKSHOP. He is also thankful to the ADGM(R) and DDGM(C) for their encouragement. Thanks are also due to the DTP Section, IMD, Pune for the work of typesetting and printing.

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Agricultural Drought Management in India

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Introduction

India, receives the major quantum (74%) of its annual rainfall during southwest monsoon season (June to September). Due to large inter and intra-annual variability in rainfall, the country witnesses frequent droughts in some parts or the other in each year and at times, over large area. In extreme northwest region, rainfall deficits are recorded over consecutive years, leading to near famine conditions. Although no part of India is immune from the adverse impacts of drought, the arid and dry semi-arid regions in the western, northern, and peninsular parts of the country experience more frequent droughts, at times leading to crippling impact on national economy. The Indian economy, thus, has been described as a 'gamble monsoon'. A perusal with the last 10 years rainfall and the corresponding food grain production (Table 1) indicate that the rainfall deficiency was -19 and -23 percent in two severe drought years (2002 and 2009) which have reduced the food grain production by 17.8 and 7.5 percent, respectively compared to the previous years production that received good rains.

***Table1**: Rainfall departures and food grain production in the country (2000-2009)*

Year	Rainfall departure (%)	Food grain production (M Tons)
2000	-11	196.13
2001	-15	212.00
2002	19	174.20
2003	+2	213.40
2004	-13	198.36
2005	-1	208.60
2006	0.7	217.28
2007	1.0	230.67
2008	-2.0	234.47
2009	-23	216.85*

**Provisional Estimates*

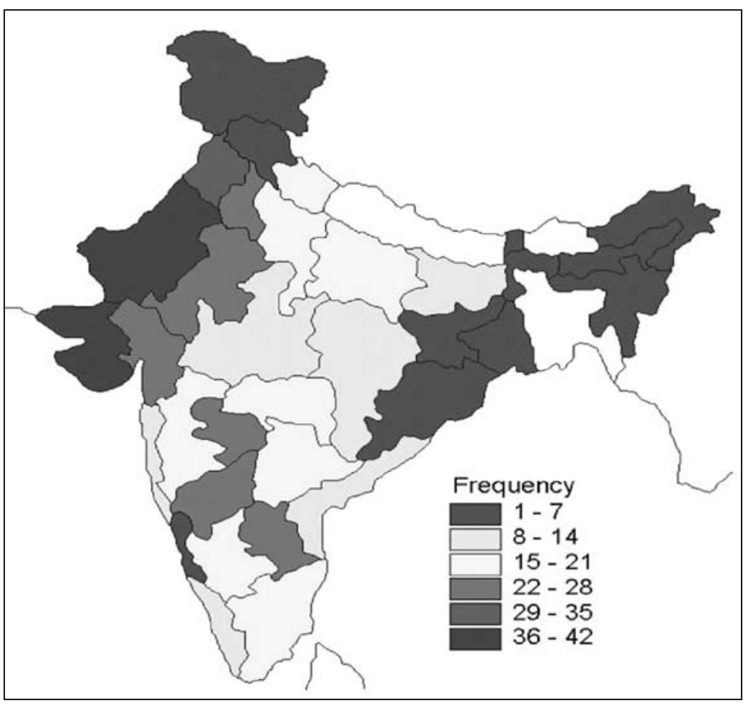


***Figure 1:** Drought frequency in India during 1870-1999*

The frequency of droughts computed based on rainfall departures over the last 200 years (Figure1) indicated that maximum number of droughts were observed in north western India followed by central parts of the country and least in NE regions and in hilly regions. The impacts of droughts have increasingly drawn the attention of scientists, planners and the Government. The vulnerability to drought in relation to increasing food needs of the growing population has become a point of great concern to Government of India.

Definition of drought

Drought is a climatic anomaly, characterized by deficient supply of moisture resulting either from sub-normal rainfall, erratic distribution, higher water need or a combination of all the factors (Ramakrishna et al, 2000). It is called as disaster in slow motion and the area covered is large. If it persists over two to three years, it may lead to famine condition. It would affect various human activities and lead to problems like widespread crop failure, unreplenished ground water resources, depletion in lakes/reservoirs, shortage of drinking water and reduced fodder availability etc. Often a region adopts itself to a certain level of water shortage based on the long-term climatic conditions experienced by it. Because drought affects many economic and social sectors, scores of definitions have been developed by variety of disciplines and the approaches taken to define it also reflect regional and ideological variations (Wilhite, 2000).

Broadly droughts have been classified into three categories, viz. Meteorological, Hydrological and Agricultural droughts.

Meteorological drought	A situation when there is significant decrease (> 25%) of normal rainfall over an area.
Hydrological drought	Meteorological drought, if prolonged, will result in hydrological droughts with marked depletion of surface and ground water level.
Agricultural drought	It occurs when both rainfall and soil moisture are inadequate during growing season to support a healthy crop.

History of droughts in India

The severe drought years that occurred over the past 210 years in the country as reported by Kulshreshta (1997) and updated by CRIDA in 2009 are shown in Table 2.

Table 2 *: All India droughts during past 200 years*

Period	Drought years	No. of years
1801-25	1801,04,06,12,19,25	6
1826-50	1832, 33, 37	3
1851-75	1853, 60, 62, 66, 68, 73	6
1876-1900	1877*+, 91, 99*+	3
1901-25	1901*, 04, 05*, 07, 11, 13, 15, 18*+, 20, 25	10
1926-50	1939, 41*	2
1951-75	1951, 65*, 66, 68, 72*,+, 74	6
1976-2000	1979*, 82, 85, 87*+	4
2000-2009	2002*+, 2009*	

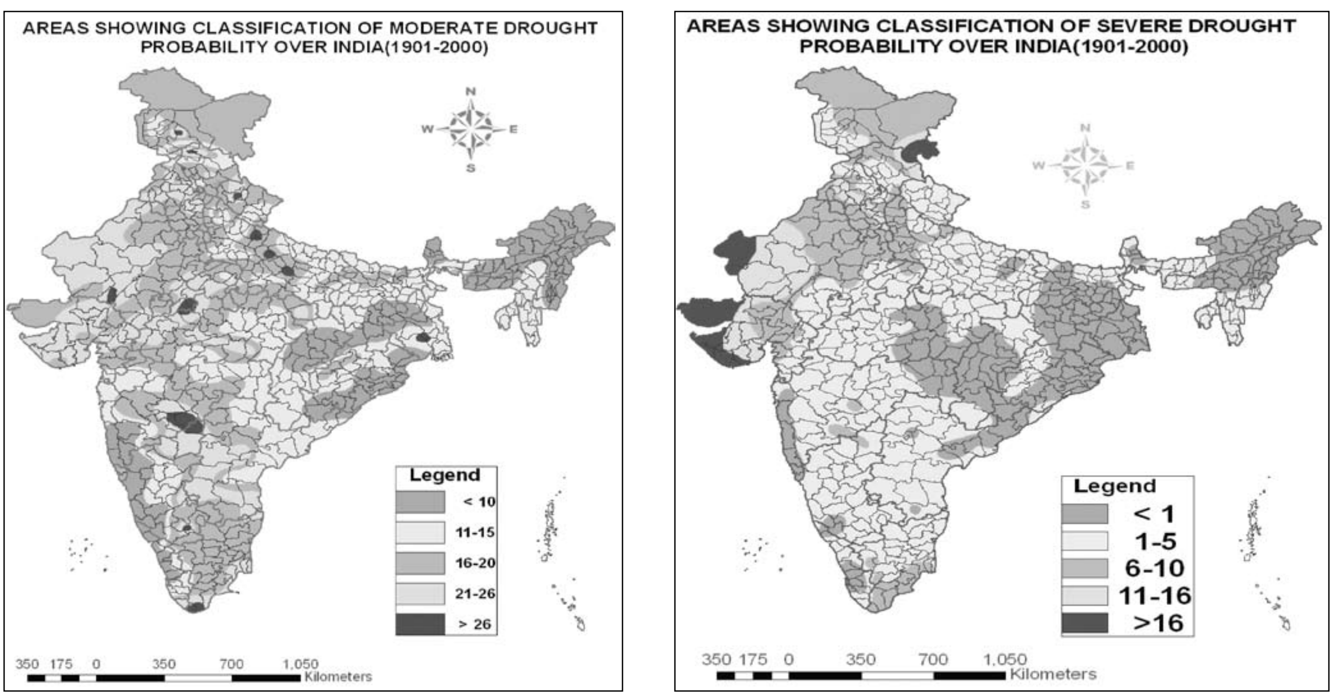
** Severe drought years = 10 (> 39.5% area affected)*
+ Phenomenal drought years = 7 (> 47.7% area)
*Source**: Kulshrestha (1997)***

The first quarter of the last century recorded 10 drought years out of which 3 years, viz., 1901, 1905 and 1918 were severe drought years. Again the last quarter of the 20th Century also recorded two severe drought years in 1979 and 1987. Similarly, first decade of the current century recorded two severe drought years that affected the agricultural production over the country considerably. Over the last 210 years, there were a total of six phenomenal drought years, viz., 1877, 1899, 1918, 1972, 1987 and 2002 when the affected area was roughly 50 percent.

The northwestern parts of the country have experienced continuous three-year drought especially in west Rajasthan and parts of Gujarat during 2000-2002.

Spatial and temporal distribution of droughts in India

A study of moderate and severe droughts that occurred in India (Figure 2) indicate that, except for very small pockets in the Northeastern India and Kerala, there were no areas, which have not been affected by drought at one time or the other. While the entire country could thus be considered as drought prone, there are certain areas, which are chronically subject to such condition and merit the appellation 'drought prone' (Table 3). Technical Committee on Drought Prone area Programmes and Desert Development Programme identified about 120 million ha of the country's area, covering 185 districts (1173 development blocks) in 13 states as drought prone (Anonymous, 1994). Based on the historical records, Jaiswal and Kolte (1981) reported 120 drought /famine like incidences in one or other part of the country between 1291 and 1978.



Moderate ***Severe***

Figure 2 *: Spatial distribution of moderate and severe drought probabilities in India (Source: Gore et al, 2010)*

Chances of experiencing moderate droughts greater than 20 percent spread across greater part of the country whereas higher probabilities of experiencing severe drought are most confined to extreme northwest portion of Gujarat and Rajasthan (Table 3).

Table 3 *: Probability of Occurrence of Drought in Different Meteorological Subdivisions of India*

Meteorological subdivision	Frequency of deficit rainfall (75% of normal or less)
Assam	Once in 15 years
West Bengal, Madhya Pradesh, Konkan, Bihar and Orissa	Once in 5 years
South interior Karnataka, Eastern Uttar Pradesh and Vidarbha	Once in 4 years
Gujarat, East Rajasthan, Western Uttar Pradesh	Once in 3 years
Tamil Nadu, Jammu and Kashmir and Telangana	Once in 2.5 years
West Rajasthan	Once in 2 years

Impact of Droughts

The usual impact of droughts is in terms of loss of crops, malnutrition of human being and cattle, land degradation, loss of other economic activities, spread of diseases, and migration of people and livestock (Kulshrestha, 1997). Droughts result in crop losses of different magnitude, depending on their geographic incidence, intensity and duration. The droughts not only adversely affect the food supply at the farm level but also impacts national economy. Predicted losses to agriculture in India were 50 percent during the drought of 1957-58. Ramakrishna and Rao (1991) observed that during the 1987 drought in India, the productivity of pearl millet in western Rajasthan dropped by 78, 74 and 43 percent in rainfall zones of < 300, 300-400 and > 400 mm, respectively. Victor et al., (1991) reported reduction in the productivity of groundnut and millet in Andhra Pradesh during 1987 drought year. For eastern India, the loss in production of food grains due to drought averaged over 1970-96 has been estimated to be $ 400 million, which is equivalent to 8 percent of the value of food grain production in the region (Pandey et al., 2000). The effect of drought was more pronounced on fodder availability as compared to that of food grains. The food grain production was reduced by 29.0 and 17.6 mt during 2002 and 2009 drought years due to reduction in net sown are in kharif season compared to previous years that received good rains. Though the rainfall departure during 2009 was higher than in 2002, the fall in food grain production over the previous year was comparatively less in 2009 compared to drop in production (29 mt) in 2002. This has been mainly due to better contingency strategies planned and adopted during 2009-10 season and the greater resilience of Indian agriculture to drought now than in the past.

The duration of availability of water in surface water bodies was reduced significantly during 1987 drought year (Narain et al., 2000). The water storage in major reservoirs were 33 percent less than the average of previous 10 years (Samra, 2004). Around 150 million cattle were affected due to lack of fodder availability. The groundwater table in drought affected areas was declined by 2 to 4 mts below the normal.

Droughts affect the livestock in several ways. Reduced productivity and mortality are the direct effects. Driven by enhanced livestock pressure due to depletion of forage resources during drought, overgrazing and indiscriminate cutting of vegetation takes place leading to land degradation. This is followed by first distress sale of cattle and even small ruminants. Migration is the next step extending the problems of uncontrolled and overgrazing, thus degrading land in other areas. There have been instances that large-scale mortality of livestock and mismanagement in disposal of their carcass caused epidemic situations and environmental hazards. Decrease in size of herd (up to 52%) was reported due to frequent occurrences of droughts in Rajasthan (Anonymous, 1994).

Management of Drought – Research & Development

Research Initiatives

The Climatology Group at the Department of Meteorology, Andhra University, Visakhapatnam initiated studies on drought in 1960 using water balance approach and India Meteorological Department established a Drought Research Unit and classified droughts based on rainfall departures. Simultaneously, ICAR has also initiated work on impacts of droughts on agriculture through its Research Institutes, viz., Central Soil & Water Conservation Training & Research Institute, Dehradun; Central Arid Zone Research Institute, Jodhpur; Indian Agricultural Research Institute, New Delhi and Central Research Institute for Dryland Agriculture, Hyderabad since their inception.

Keeping in view of the productivity gap between irrigated and rainfed areas, the Fourth Five Year Plan (1969-74) emphasized the need for extending the advancements in science and technology to dryland areas. More emphasis was laid on research related to dryland agriculture. The All India Co-ordinated Research Project on Dryland Agriculture (AICRPDA) was established at 24 centres in 1970 to tackle the problems of dryland agriculture, which are highly location-specific.

The ICAR has started an All India Coordinated Research Project on Agrometeorology, which is operating at 25 centres from 1995 onwards. These centres are providing weather-based agro-advisories to farmers in different agroclimatic regions of the country in addition to agroclimatic planning, contingency measures for different weather situations and disseminated through ICT facilities including mass media involving State Agricultural Universities as the main vehicle.

International Institutes like ICRISAT started in 1972 also helped semi-arid farmers in managing dryland crops, viz., sorghum, pearlmillet, pigeonpea and groundnut for stable production under aberrant weather conditions. Enhancing production through watershed and farming system approach are strategies suggested by ICRISAT for climate risk management. A number of Research Institutes of ICAR and State Agricultural Universities are conducting considerable research work on developing drought and heat tolerant varieties and soil and water conservation measures, which help in combating drought and stabilizing crop production. A brief summary of these technologies is given in the following section.

Strategies and technologies to combat drought

Following are the various improved techniques and practices recommended for drought management in rainfed areas:

Crop Planning: Crop varieties for dryland areas should be of short duration drought resistant/tolerant which can be harvested within rainfall periods and have sufficient residual moisture in soil profile for post-monsoon cropping.

Crop Substitution: Traditional crops/varieties, which are inefficient utilizers of soil moisture (due to long duration), less responsive to external inputs and low yielders should be substituted by more efficient ones.

Cropping Systems: Increasing the cropping intensity by using the practice of intercropping and multiple cropping results in more efficient utilization of resources. The cropping intensity would depend on the length of growing season, which in turn depends on rainfall pattern and the moisture storage capacity of the soils.

Fertilizer use: Dryland soils are not only thirsty, but also hungry. Therefore, application of fertilizers should be done in furrows below the seed. The use of fertilizers not only helps in providing nutrients to crop but also leads to efficient use of soil moisture. A proper mixture of organic and inorganic fertilizers improves moisture holding capacity of soils and enhances drought tolerance.

Rain water management: Efficient rainwater management can increase agricultural production from dryland areas. Application of compost and farmyard manure and raising legumes add organic matter to the soil and increase the water holding capacity. The water, which is not retained by the soil, flows out as surface runoff. This excess runoff water can be harvested in situ by proper land treatments or stored in dugout ponds and recycled to for supplemental irrigation.

Watershed management: Watershed management is a approach to optimize the use of land, water and vegetation in an area and thus, to provide solution to droughts, moderate floods, prevent soil erosion, improve water availability and increase fuel, fodder and agricultural production on a sustained basis.

Alternate land use: All drylands are not suitable for crop production. Some lands may be suitable for range/pasture management, ley farming, dryland horticulture, agro-forestry systems including alley cropping. All these systems, which are alternative to crop production, are called as alternate land use systems. These systems help to generate off-season employment in mono-cropped drylands and also, minimize risk, utilize off-season rains, prevent degradation of soils and restores balance in the ecosystem. Different alternate land use systems are alley cropping, agri-horticulture and silvi-pasture.

Managing drought during different crop stages

Specific recommendations to mitigate dry spells occurring in different crop stages are available for different regions of the country.

a. Early Season Drought

Early season droughts occur due to delay in commencement of sowing rains. Sometimes, early rains may occur tempting the farmers to sow the crops followed by a long dry spell leading to withering of seedlings and poor crop establishment.

- The management options to cope up with early season drought are:
- Raising community nurseries for cereal crops and transplant the seedlings with the onset of rainy season.
- Sowing of alternate crops/varieties depending upon the time of occurrence of sowing rains. The seeds may not be available to the farmers and government should provide seed through seed banks promoting seed villages.
- If there is a poor germination and inadequate plant stand, resowing is recommended. Seed priming helps in better crop establishment.

b. Mid-Season Drought

Mid-season drought occurs due to long gaps between two successive rainy events when the moisture available in the soil falls short of water requirement of the crop during the dry period.

The management options to cope-up with the mid season droughts are:

- Rain water harvesting and recycling for life saving irrigation
- Reducing crop density by thinning
- Weed control and mulching
- In-situ moisture conservation
- Dust mulching, repeated harrowing
- Use of anti-transparents

c. Late Season Drought

If the crop encounters moisture stress during the reproductive stage due to early cessation of rainy season, there may be rise in temperature, hastening the process of crop maturity. The grain yield of crops is highly correlated with the water availability during the reproductive stage of growth. Short duration high yielding varieties may escape late season droughts. Another possibility is to provide supplemental irrigation from harvested rainwater. Organic mulches are found to be useful in improving crop yields during post-rainy season. When crops are sown late, terminal drought can be anticipated with greater certainty. Therefore, varieties that respond better to terminal droughts have to be preferred.

Soil and water conservation measures

The Soil and Water Conservation (SWC) are the most important components of drought management (both temporary and permanent). SWC measures are essential for in-situ conservation of soil and water. The main aim of these practices is to reduce or prevent either water erosion or wind erosion, and enhancing moisture in soil for sustainable production. The suitability of in situ soil and water management practices depend greatly upon soil type, topography, climate, cropping system and farmers' resources.

Some of the most common in situ conservation practices followed in India are described below:

a. Contour cultivation

Contour cultivation is a simple method of cultivation across the slope which effectively reduces the runoff and soil loss on gentle sloping lands. In this, all field operations such as ploughing, planting and inter-cultivation are performed on the contour (Figure3). It helps in reduction of runoff by impounding water in small depressions and reduces the developments of rills. Maximum effectiveness of this practice is on medium slopes and on permeable soil.

b. Conservation furrow

Conservation furrow is a simple and low cost in situ soil and water conservation practice for areas with moderate slope. This practice is suitable for soils with problems of crusting, sealing and hard setting. In this system, series of furrows are opened on contour or across the slope at 1-3 m apart (Figure3). The spacing between the furrows and its size can be chosen based on the rainfall, soils, crops and topography. The furrows can be made either during planting time or interculture operation using country plough. Two to three passes in the same furrow may be needed to obtain the required furrow size. These furrows harvest local runoff and improve the soil moisture in the adjoining crop rows particularly during the period of water stress. This practice increases crop yields by 10-25 percent and it cost around Rs. 250-350 ha-1. To improve its effectiveness further, it is recommended to use this system along with contour cultivation or cultivation across the slope (Ram Mohan Rao et al., 1981, Mishra et al., 2010).

c. Broadbed and furrow system

On black soils, the problem of water logging and water scarcity occurring during the same season are quite common. The in situ conservation practice should store water in the profile and drain excess water. The "Broadbed and Furrow" (BBF) system successfully meets these goals. The BBF system consists of a relatively raised flat bed or ridge approximately 90 cm wide and shallow furrow about 30 cm wide and 15 cm deep. The BBF system is laid out on a grade of 0.4 – 0.8 % for optimum performance. It is important to attain a uniform shape without sudden and sharp edges because of the need to plant rows on the shoulder of the broadbed.

Figure 3 : *Most common in situ conservation practices (a) contour cultivation (b) conservation furrow (c) broad bed and furrow system*

d. Vegetative barriers

Vegetative barriers or vegetative hedges or live bunds are effective in reducing soil erosion and conserving moisture. In many situations, the vegetative barriers are more effective and economical than mechanical measures, viz., bunding. Vegetative barriers can be established either on contour or on moderate slope of 0.4 to 0.8 percent. In this system, the vegetative hedges act as a barrier to runoff flow and slowing down the velocity resulting in deposition of eroded sediments and increased rainwater infiltration. It is advisable to establish vegetative hedges on small bund. This increases its effectiveness, particularly during the first few years when the hedges are not so well established. If the main purpose of the vegetative barrier is to act as a filter to trap the eroded sediments and reduce the velocity of runoff, then grass species such as vetiver, sewan (Lasiurus sindicus), sania (Crotolaria burhia) and kair (Capparis aphylla) are recommended. If the purpose is to stabilize the bund, plants like Gliricidia could be used. Gliricidia plants grown on bunds not only strengthen the bunds, but also provide N-rich green leaf biomass, which can be added on soil as mulch-cum-manure.

Water harvesting and ground water recharge

While in situ conservation practices are appropriate at farm level, at community or landscape level, harvesting surplus runoff for surface storage or ground water recharge are more important measures for drought proofing.

a. Check dams

Masonry check dams are permanent structures used for controlling gully erosion, water harvesting and groundwater recharging (Figure4). These structures are popular in watershed programs in India. These structures are preferred at sites where velocity of runoff in gullies/streams is very high and stable structure is needed to withstand the flow. Masonry check dams are designed on the basis of rainfall-runoff relationship. Depending upon the assumed depth of structure and the corresponding area to be submerged, suitable height of the dam may be selected to provide adequate storage in a given topographic situation (Katyal et al., 1995).

Earthen check dams are very popular in the watershed programs in India for controlling gully erosion and for harvesting runoff water. These are constructed using locally available materials. The cost of construction is generally low. The size of the dam depends on the site conditions. In some cases, stone pitching may be required to protect the bund from scouring. Earthen check dams are used as surface water storage structures as well as for recharging groundwater.

b. Khadin system

'Khadin' is a land-use system developed centuries ago in the Jaisalmer district of Western Rajasthan. This system is practiced by single large farmer or by group of small farmers. It is highly suitable for areas with very low and erratic rainfall conditions. In khadin system, preferably an earthen or masonry embankment is made across the major slope to harvest the runoff water and prevent soil erosion for improving crop production. Khadin is practiced where rocky catchments and valley plains occur in proximity. The runoff from the catchment is stored in the lower valley floor enclosed by an earthen/stone 'bund'. Any surplus water passes out through a spillway. The water arrested stands in the khadin throughout the monsoon period. It may be fully absorbed by the soil during October to November, leaving the surface moist. If standing water persists longer, it is discharged through the sluice before sowing. Wheat, chickpea or other crops are then planted. These crops mature without irrigation. The soils in the khadins are extremely fertile because of the frequent deposition of fine sediment, while the water that seeps away removes salts. The khadin is, therefore, a land-use system, which prevents soil deterioration (Kolarkar et al., 1983). This practice has a distinct advantage under saline groundwater condition, as rainwater is the only source of good quality water in such area.

c. Farm ponds

Farm ponds are very age old practice of harvesting runoff water in India. These are constructed by excavating soil from a low lying area of the field (Figure4). Following guidelines are to be followed in design and construction of farm ponds.

- High-storage efficiency (ratio of volume of water storage to excavation) can be achieved by locating the pond in a gully, depression, or on land having steep slopes. Whenever possible, use the raised inlet system to capture runoff water from the upstream. This design will considerably improve the storage efficiency of the structure.
- Seepage losses can be minimized by selecting the pond site having subsoils with low saturated hydraulic conductivity. As a rough guide, the silt and clay content of the least conducting soil layer is inversely linked with seepage losses. Therefore, it is best to select the site having subsoil with higher clay and silt and less coarse sand. Also, reduce the pond wetted surface area in relation to water storage volume. This can be achieved by making the pond of a circular shape or close to circular shape.
- Evaporation losses can be minimized, if the ponds are made deeper but with acceptable storage efficiency to reduce water surface exposure and to use smaller land area under the pond.

a. Check dam

b. Farm pond

Figure4 : *Common water harvesting structures*

Water harvested in the pond could be used for providing supplemental irrigation to kharif crops during dry spells. Best returns are possible with cash crops or vegetables. Recent research by CRIDA resulted in design of low lift diesel run pumps (1.5 Hp) which are portable and can be used more profitably to lift water from ponds. This water can be conveyed either through sprinklers or drips (Figure5).

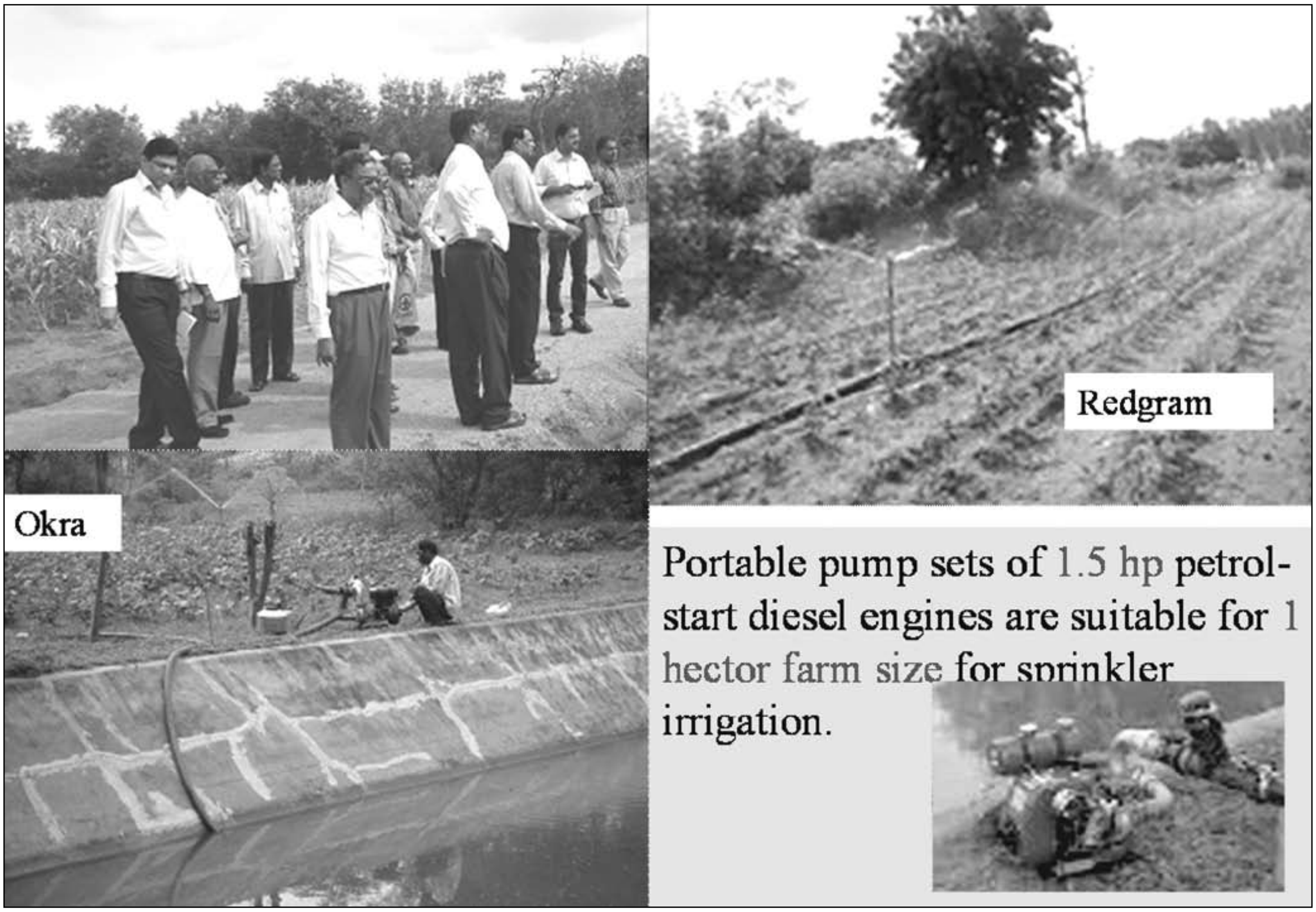


***Figure 5** : Pond water for life saving irrigations using portable pumpset*

Development Efforts in Drought Management

Short-term relief measures

Drought relief measures are implemented as soon as the distress signals are visible. These measures are location-specific and require good cooperation and coordination among various departments. It requires continuous flow of information from village to administrative units and back. Some of the measures to reduce impact of drought implemented by Government of India through State Governments are described below.

Relief employment

Central and State Governments initiate relief works to provide employment during drought. Most recently, the Government of India has started the National Rural Employment Guarantee Scheme (NREGS) in 2005 by providing 100 days of employment per year to adult members of family who were willing to undertake manual work for creation/development of public assets at the statutory minimum wage. The Government is planning to increase days to 150 in drought years due to its success rate. The program also permits individual beneficiary works such as farm ponds, new wells/deepening of existing wells, construction of new water channels, rainwater harvesting structures, all of which contribute to drought proofing.

Augmenting drinking water supply

Water is the basic need for human and cattle population. Supply of drinking water during droughts is the responsibility of the State Government. Measures taken by the Government for management of water resources includes (1) repair and augmentation of existing water supply schemes, (2) special measures and schemes for areas with acute drinking water scarcity, (3) construction of temporary piped water supply, (4) digging of new bore wells, and (5) supply of water through tankers and bullock carts.

Ensuing food grains availability

Supplying food grains through Public Distribution System (PDS) was initiated from 1965-66 which is jointly operated Central and State Governments. The PDS with a network of about 4.74 lakhs fair price shops in the country is one of the largest networks in the world. Since 1977, targetted PDS was introduced which follows a two tier subsidized pricing for people "Below Poverty Line (BPL)" and "Above Poverty Line (APL)". Community kitchens for certain segments of people such as old, disabled and women are run either by Government or through NGOs during extreme drought situations.

Cattle camps and fodder supply

To prevent the distress sale of cattle during drought years, the State Governments organize cattle camps in the affected regions and protect animals against starvation and diseases by transportation of fodder and feed from the areas where the situation is not alarming and need based vaccination. Government also encourages farmers in drought prone areas to undertake fodder cultivation on the banks of canals, tank beds or other areas under irrigation.

Contingency crop planning

Contingency crop planning is the most important short term strategy for drought management. The State Agricultural Universities and ICAR Institutes have formulated contingency plans for delayed monsoon, mid-season breaks and early withdrawal. These are available at state or agroclimatic zone level. In order to make them more useful and effective, ICAR, in collaboration with State Agricultural Universities and State Agricultural Departments are preparing district level contingency plans by pooling and analyzing all the relevant natural resources information of each district to cover all weather aberrations like droughts, floods, cyclones, heat wave, frost, etc. It is planned to prepare these plans for all 600 districts in the country by the year 2010-11. In addition to crops, livestock and fisheries are also covered in this program.

Agro-advisories

The India Meteorological Department (IMD) through its Integrated Agro-advisory Services are issuing weather-based advisories at the district level covering all 127 agroclimatic zones using the medium range forecast (3 to 4 days) and the crop conditions in collaboration with ICAR Research Institutes and the State Agricultural Universities. All the centres of All India Coordinated Research Project on Agrometeorology are also participating and the research results generated through this project are being used for formulating advisories. These are disseminated through various mass media and placed on the websites of ICAR, IMD and SAUs.

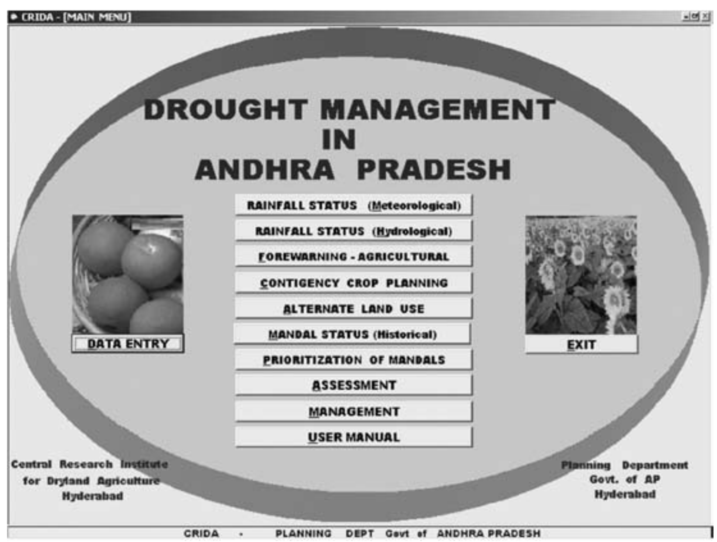
Scientists of State Agricultural Universities also reach farmers through radio, television, newspapers and contact farmers. The economic benefits accrued due to agro-advisories can be seen in Table 4.

***Table 4** : Impact of Agro-advisories on farmers income*

Location	Crop	Advisory given	Benefit to the farmer
Jammu	Maize Rice	Timing of irrigation	Rs.750/ha
Trissur	Banana	Timing of irrigation	Rs.1275/ha
Kovilpatti	Cotton	Pre-monsoon sowing	Rs.1000-1500/ha
Bhubaneswar	Kharif Rice	Delaying pesticide spray	Rs.850/ha
Ranga Reddy	Grapes	Spraying of fungicide	Rs.31000/ha

Use of ICT: Decision Support System (DSS) for Drought Management

A Decision Support System (DSS) is an integrated interactive computer based system consisting of analytical tools and information management capabilities designed to aid decision makers. A DSS typically consists of data bases, modeling tools and documentation of the decision making process. DSS could be used to provide timely information which will support the decision makers. .



CRIDA has developed drought management plan for 1200 mandals and 22 districts of Andhra Pradesh. The mandals prone to drought were assessed and prioritized using bio-physical and socio-economic parameters. Drought severity indices were worked out for all the mandals. A DSS was developed with diverse modules dealing with assessment, mitigation and relief measures to reduce the time lag in collection, processing and transfer of data/information. Forewarning for agricultural drought was attempted for the first time on real time basis. The inputs include daily rainfall, maximum and minimum temperature for deriving PET, crop coefficient, available water content (AWC) for a given soil type, maximum yield of crop, duration of the crop and sowing date. Information on groundwater, surface water and livestock management are also included in the DSS. Drought preparedness is much more cost-effective than expenditure on relief measures.

National Agricultural Drought Assessment and Monitoring System (N- ADAMS)

An agricultural drought information and monitoring system has been launched in India using satellite data under the project 'National Agricultural Drought Assessment and Monitoring System (NADAMS) in 1989 by National Remote Sensing Agency (NRSA). Under NADAMS, agricultural conditions are monitored at state level using daily observed coarse resolution (1.1 km) NOAA AVHRR data for the entire country and at sub district level for Andhra Pradesh and Karnataka using higher spatial resolution IRS WIFS data (188m). Fortnightly bulletins were issued at district level for 11 states in the country during 1989 to 1991. Since 1992, detailed monthly reports at the end of August for June, July and August and the monthly updates thereon for the period of September and October are prepared and sent to the concerned authorities for preparation of contingency plans.

Medium-term strategies

Integrated Watershed Management Programme (IWMP)

The Government of India considers Watershed Program as the principal vehicle for drought proofing in rainfed areas. Till 2007 investments made by various agencies on watershed implementation are Rs.194706 million and the area treated is about 56.5 m ha with an average investment of Rs.3444 per hectare as per the assessment of Planning Commission.

In 1999-2000, NABARD has established a Watershed Development Fund (WDF) to enable states to access credit for treatment of large areas under watershed development (Government of India, 2000). National Rainfed Area Authority (NRAA) has recently formulated new common guidelines for Watershed Programs in 2008 where large area upto 5000 ha are to be covered which provides opportunities for resources conservation and drought proofing.

Integrated Water Resources Management

Since water has an economic value, it is important that the competing uses for water must be reconciled in order to manage it sustainably. The Integrated Water Resources Management (IWRM) strategy of the Government of India aims to achieve this objective by considering water as a single resource unit regardless of different uses to which it is put to. IWRM aims to ensure the coordinated development and management of water, land and related resources by maximizing economic and social welfare without compromising the sustainability of the vital ecological systems.

Improving Water Use Efficiency

Even after all the ultimate irrigation potential is developed in India, more than 50 percent of the cultivable land will still remain under rainfed cultivation. In addition to improving the performance of existing irrigation systems, higher efficiency in water use need to be ensured to meet increasing demands. ICAR and SAUs through their research efforts have evolved many improved irrigation methods, zero tillage, raised bed planting, breeding low water requiring varieties, etc. for enhancing the water use efficiency. However, micro-irrigation methods will be the key component for achieving water use efficiency.

Crop Insurance Scheme

Crop insurance was introduced in India during kharif 1985, a the Comprehensive Crop Insurance Scheme (CCIS) . One of the basic objectives of the scheme was "to provide a measure of financial support to farmers in the event of crop failure due to droughts, floods etc." But the scheme was voluntary and states were free to join the scheme. Only few food grain crops such as wheat, paddy, millets (including maize) and oilseed and pulses were covered in the scheme. Based on initial experiences, the scheme was revised as Experimental Crop insurance Scheme (ECIS). This was further improved and a Modified Comprehensive Crop Insurance Scheme (MCCIS) was introduced in kharif, 1999. In 2009-10, as many as 27 million farmers growing crops on 38 m ha were insured by Agricultural Insurance Company (AIC) alone.

Weather-based Insurance

As the Crop Insurance Scheme has some limitations such as long time for settlement of claims, weather-based insurance is now becoming popular with the farmers. This is relatively a new concept and high level of transparency is maintained. Pay out structures are developed to compensate farmers to the extent of losses deemed to have been suffered using weather triggers. It is rapidly becoming popular due to quick settlement of claims and greater transparency.

Long-Term Strategies

Increasing Irrigation Potential

At present, out of 142 million hectares cultivated area in India, only 58 m ha is under irrigation. Ground water provides 60 percent of the irrigation and hence ground water recharge schemes, sustainable exploitation, demand management are critical to maintain India's irrigation potential. Going by past trend, irrigation is extended by around four million hectares every five years. By extrapolating this trend, it is projected that about 20 million ha additional area is likely to be brought under irrigation in the next 25 years. This will still leave nearly 64 million hectares under rainfed conditions. Bringing all the area under irrigation is not possible in the near future and hence drought management continues to be an important agenda for India for long time to come.

River Linking

Linking major rivers in India to transfer surplus water in some rivers to others experiencing deficit where the basins are almost closed is another option to manage droughts in India. Several feasibility studies have been commissioned on the subject and few small rivers have been linked. High level task forces are working on the proposal but in view of immense political and environmental implications, it is difficult to see great progress in near future.

National level coordination and future outlook

The Department of Agriculture and Coordination (DoAC) under the Ministry of Agriculture is the nodal department for coordination of drought management in India. Indian Meteorological Department (IMD), ICAR, Ministry of Water Resources, Department of Civil Supplies and Railways all take part in this effort. A weekly inter-ministerial weather watch group monitors the rainfall and crop situation and recommends appropriate contingency measures. Recently, the National Rainfed Area Authority (NRAA) has been formed under the Ministry of Agriculture to provide technical support for development of rainfed areas including drought management. The Ministry of Agriculture has developed a manual on drought management which describes the details of the institutional, technical and logistic systems to be followed by centre and states during droughts. The National Disaster Management Authority (NDMA) under the Home Ministry has also brought out national guidelines on drought management which covers all important aspects like institutional frame-work, prevention, preparedness, mitigation, capacity building and relief response.

Climate change is adding a new dimension to drought management. As per several global models the rainfall in some regions of India is likely to decrease while in other areas it would increase. Recent rainfall trend indicate that the number of rainy days are decreasing many parts of the country and the intensity of rainfall is increasing. Long dry spells and high rainfall events are becoming more common. These challenges pose new problems for drought management. The Indian Council of Agricultural Research has already initiated a network research programme on understanding the impacting climate change on the frequency of drought and floods and evolving suitable adaptation and mitigation strategies.

Since agriculture is a state subject, all the states in India have also strong administration system for managing drought and under-taking relief measures. The Relief Commissioner and the departmental heads of agriculture, animal husbandry, fisheries and rural water supply work in tandem to implement relief measures. These measures are triggered once the state declares a particular district or blocks as drought hit. Many states in India have their own criteria for declaration of drought. However, the Government of India is in now evolving uniform indicators which can be used across the country for declaring drought. The Government of India is also taking a number of measures to improve drought forecasting and early warming systems by enhancing the forecasting capabilities of IMD and increasing the rain gauge density and modernizing weather data collection and transmission infrastructure. CRIDA, Hyderabad is working as the nodal institute under ICAR for providing technical support in drought management and formulation of contingency crop plans across the country. National Remote Sensing Centre (NRSC) in Hyderabad is also using satellite information for assessing drought intensity through Normalized Differential Vegetation Index (NDVI). In future, it is planning to integrate more indicators for drought monitoring. All these measures hopefully will help in managing droughts more effectively in future.

Conclusions

India has a long history of tackling droughts and its successful management. However, due to the large size and geographical diversity of the country, effective drought management continues to be a major challenge at the ground level. Therefore, the country is strengthening its scientific capability in weather forecasting, infrastructure for weather data collection and dissemination, institutional frame-work for implementation of contingency strategies and policy measures for risk management in order to evolve an effective drought management system.

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Rainfall Characteristics and its Distribution in Maldives

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General introduction

Maldives is a group of about 1,200 islands, separated into a series of coral atolls, only 200 of the islands are inhabited. The chain of islands stretching north-south orientation lies in the southwest of India and south-southwest of Srilanka in the Indian Ocean.

Geographically Maldives is located between 72°32'30"E 73°45'54"E and 7°06'30"N to 0°41'48"S

Total political area of the country is about 90,000 square km of which about 99% is water. The average elevation of the islands with flat topography is about Im above mean sea level. The average size of these islands are 40 - 60 heactors, the largest being 500 hectors. Non of these islands have either mountains or rivers. These low-lying islands are subjected to perennial beach erosion and stand at the mercy of any sealevel rise. Total population is about 300,000 of which 30% people live in the capital Male'.

The climate of Maldives is warm year round determined by two distinct seasons dry season (northeast monsoon) and wet season (southwest monsoon). Temperature varies very little with an annual average daily maximum of 30.4 °C and minimum at 25.9 °C.

Data coverage

Data from five meteorological stations for a period of 18 years (from 1992 - 2009) was used to analyze the rainfall characteristics and its distribution over the country.

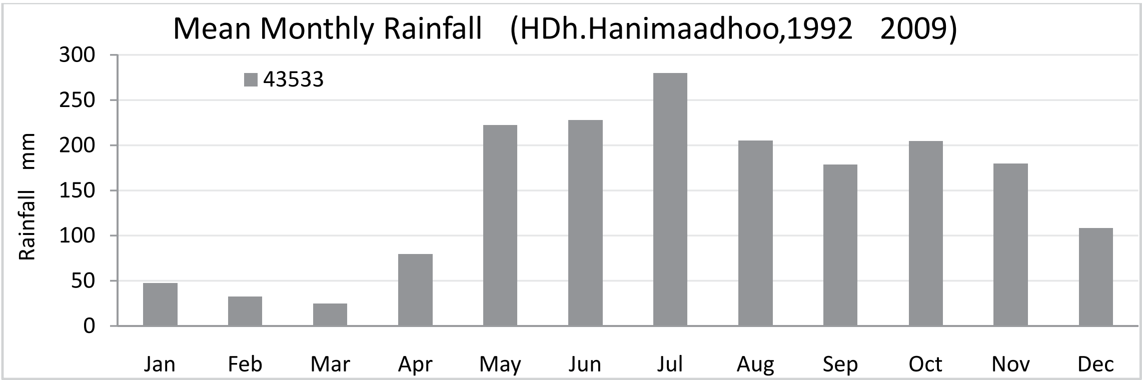
Meteorological stations used for this study are:

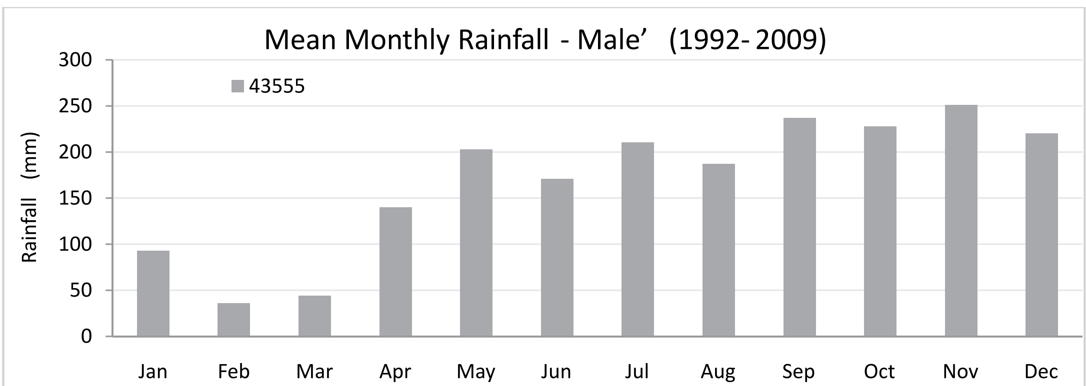
S.No	Met Station Name	WMO location Index	Geographical location	Data period
1	HDh.Hanimaadhoo	43533	06°44'39"N 073°10'13"E	1992 - 2009
2	K.Hulhule	43555	04°ll'30"N 073°31'45"E	1992 - 2009
3	LKadhdhoo	43577	01°51'33"N 073°31'19"E	1992 - 2009
4	GDh.Kaadedhdhoo	43588	00°29'17"N 072°59'49"E	1994 - 2009
5	S.Gan	43599	00°41'36"S 073°09'20"E	1992 - 2009

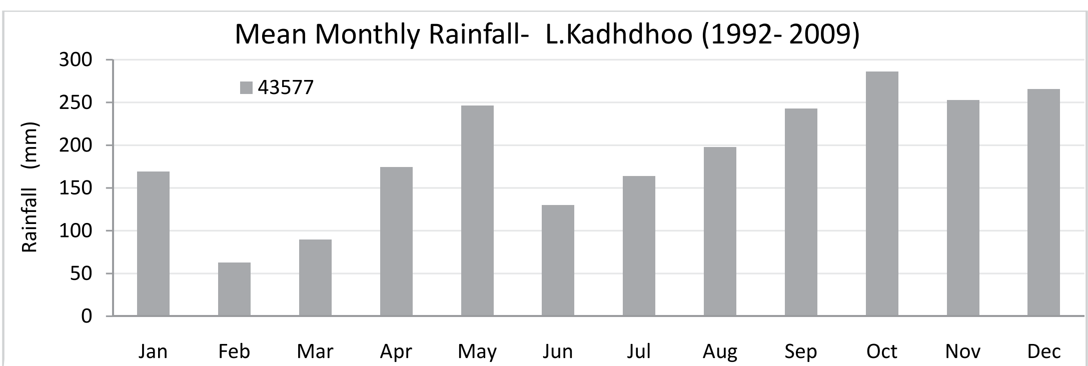
Methodologies used

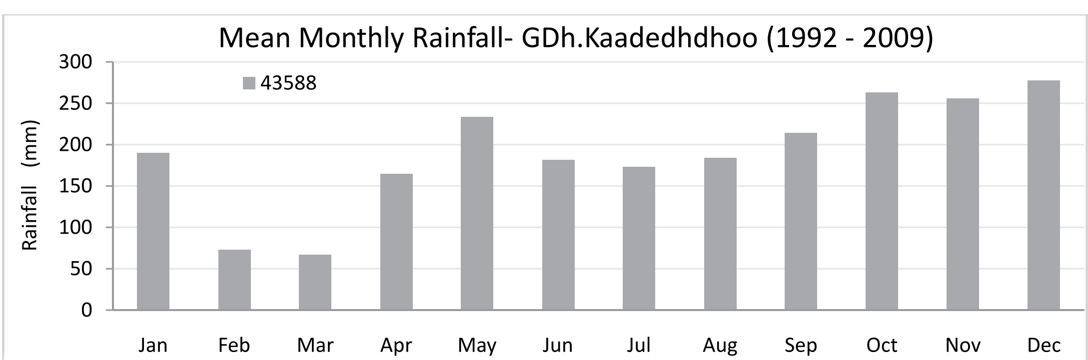
Monthly mean rainfall for the respective stations are plotted on a graph to find the seasonal distribution of rainfall for that particular station.

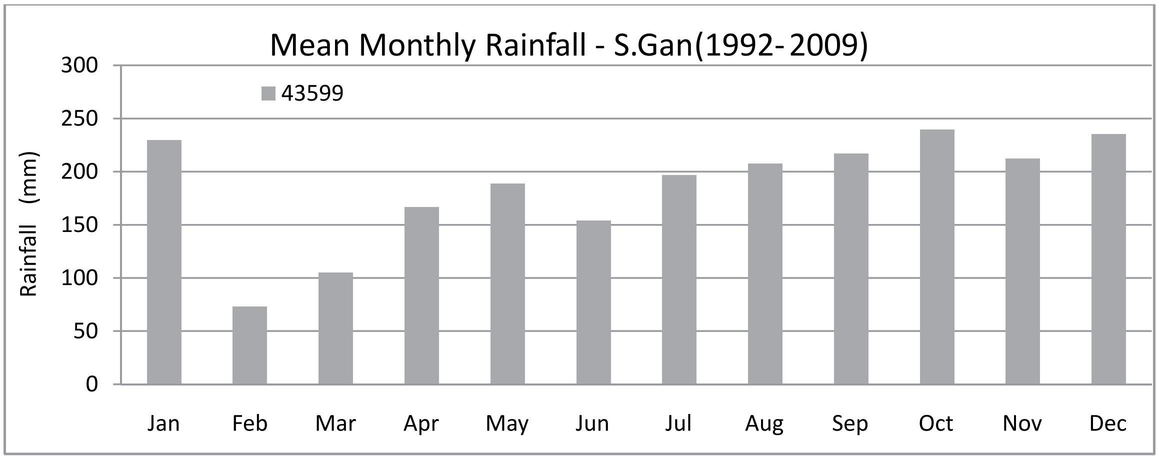
Following are the monthly rainfall graphs for the five stations.


Mean Monthly Rainfall (HDh.Hanimaadhoo,1992 2009)
43533
Rainfall mm
300
250
200
150
100
50
0
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec


Mean Monthly Rainfall - Male' (1992- 2009)
43555
Rainfall (mm)
300
250
200
150
100
50
0
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec


Mean Monthly Rainfall- L.Kadhdhoo (1992- 2009)
43577
Rainfall (mm)
300
250
200
150
100
50
0
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec


Mean Monthly Rainfall- GDh.Kaadedhdhoo (1992 - 2009)
43588
Rainfall (mm)
300
250
200
150
100
50
0
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec

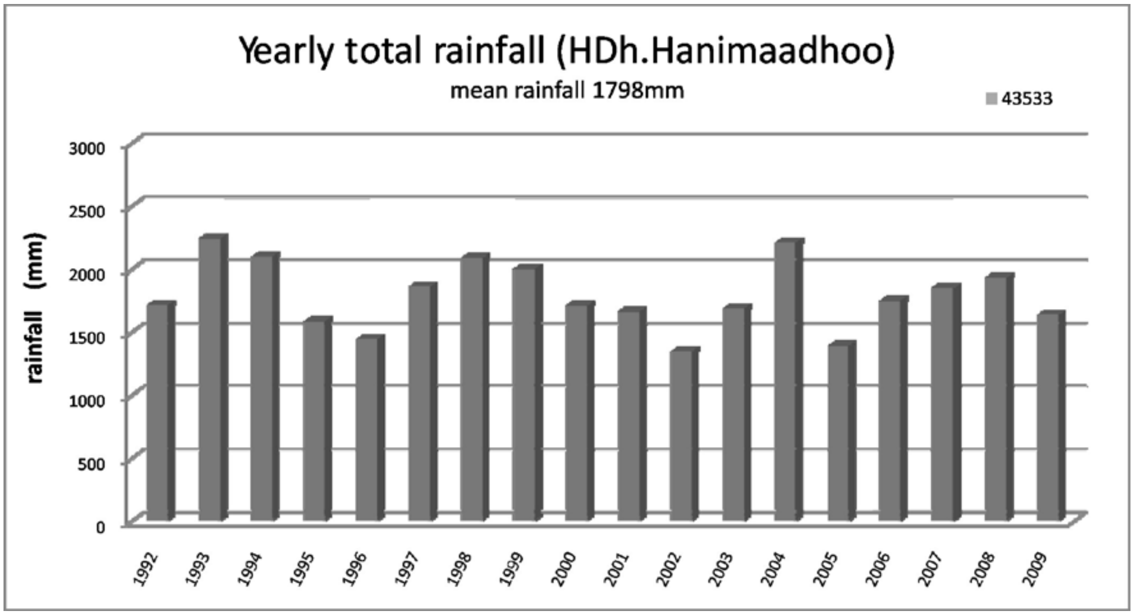


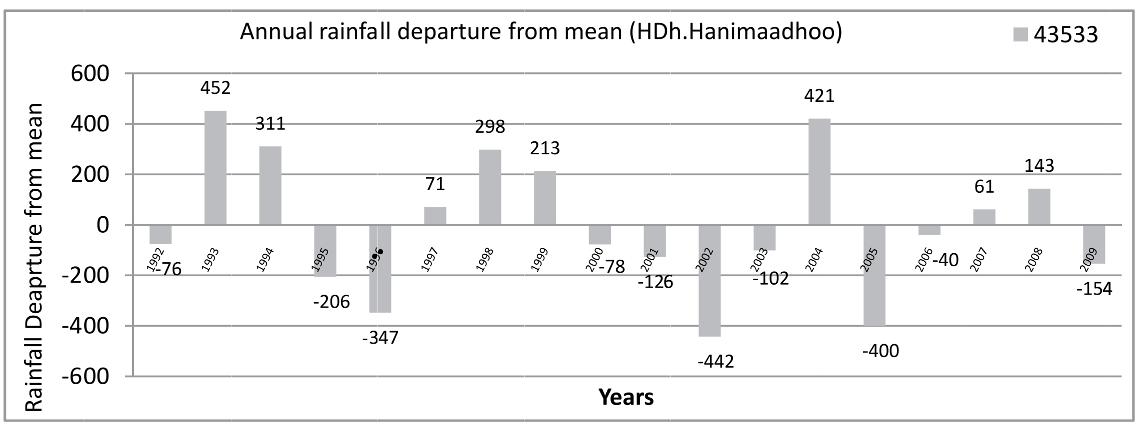
Results and discussion

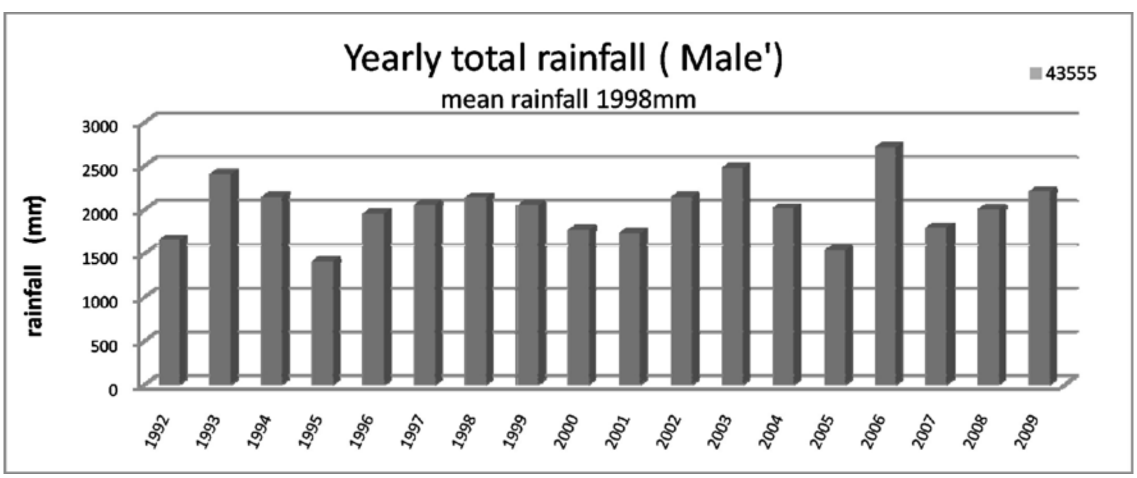
The rainfall over Maldives is predominantly affected by the movement of the Inter Tropical Convergence Zone (ITCZ), which in turn, is dependent on the north-south movement of the sun. This results in two distinct seasons in the Maldives, namely Northeast monsoon and Southwest monsoon. However the duration of these two seasons differ from north to south. It seems that the influence of Northeast monsoon over southern atolls are very less as compared to northern atolls. Though there is high intra-seasonal variability of rainfall, the duration of Northeast monsoon (dry season) is relatively short or is not very significant in southern atolls as compared to that of northern atolls. The above graphs show that the Northeast monsoon (dry season) over northern atolls extend from January to April for a period of about 4 months, but as we move from north towards southern atolls, the length of this dry period reduces for about 2 months from February to March. Normally southwest monsoon (wet season) onset to southern atolls by 1st week of May and gradually progress to north and gets fully established over the country by the last week of May. So the southwest monsoon is more pronounced and lengthier in southern atolls while southwest monsoon in northern atolls runs from mid-May to November, December being the transition period of two monsoons, bring a considerable amount of precipitation over the country.

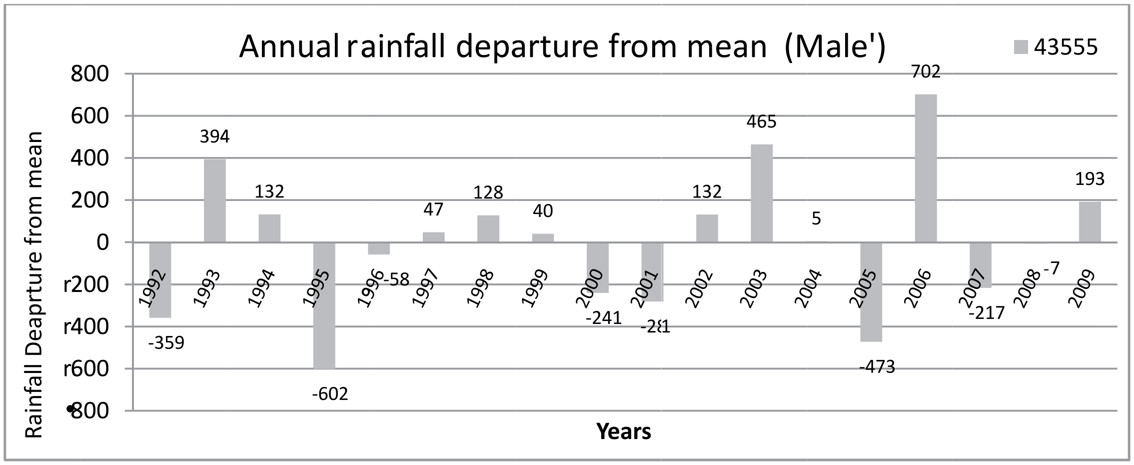
Though there is significant intra-seasonal variability of rainfall, the inter-annual variability of rainfall is relatively small.

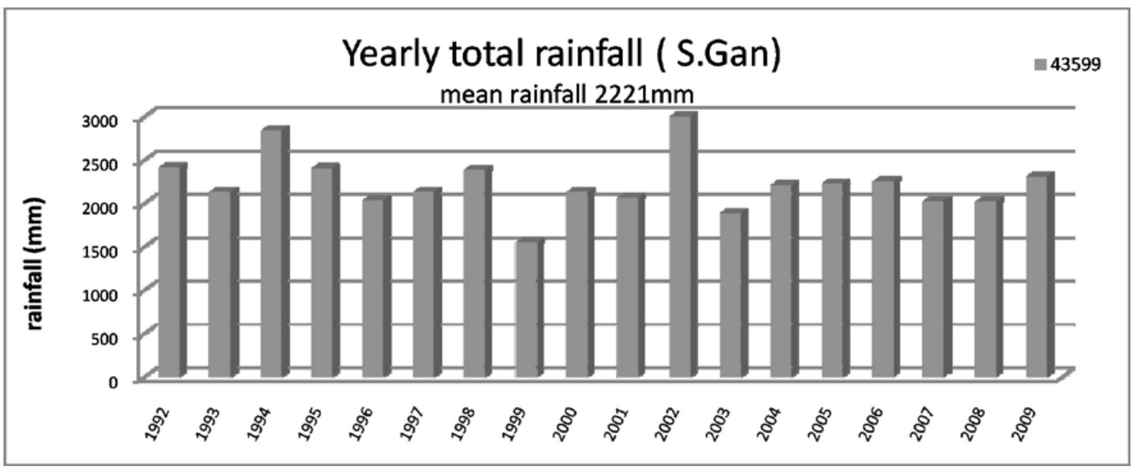
The graphs below show that the total annual rainfall for the period from 1992 - 2009 for the selected stations and their departure from the mean for the given period.

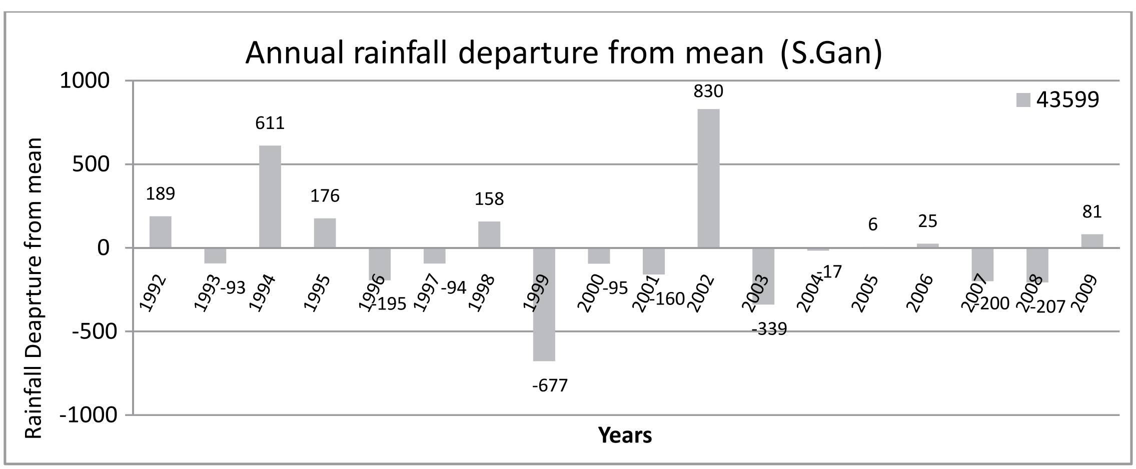

Yearly total rainfall (HDh.Hanimaadhoo)
mean rainfall 1798mm
43533
rainfall (mm)
3000
2500
2000
1500
1000
500
0
1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009


Annual rainfall departure from mean (HDh.Hanimaadhoo)
43533
Rainfall Deaprture from mean
600
400
200
0
-200
-400
-600
452
311
71
298
213
421
61
143
-76
-206
-347
-78
-126
-442
-102
-400
-40
-154
Years

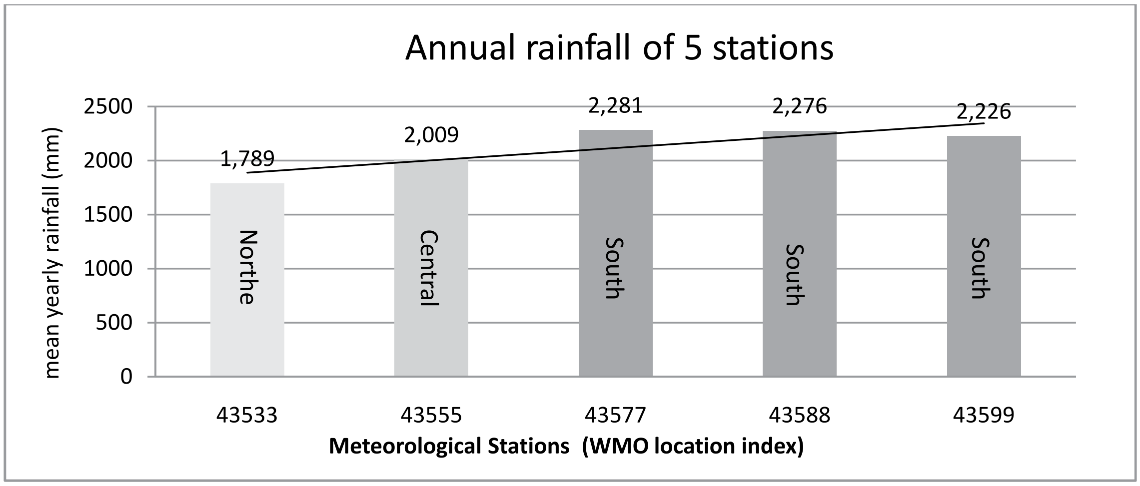

Yearly total rainfall (Male')
mean rainfall 1998mm
43555
rainfall (mm)
3000
2500
2000
1500
1000
500
0
1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009







The intra-seasonal variability of rainfall over the country, has very small impact on annual rainfall, as such the annual departure from mean seldom exceeds 700 mm.



The above graphs show that the mean annual rainfall has an increasing trend as we move from north to southern atolls.

Drought in Maldives?

With the above results and discussion, it is difficult to define draught in Maldives, however, at times when the duration of northeast monsoon (dry season) exceed to a certain limit, many islands fall shortage of fresh water for drinking and other domestic use. In most of these islands ground water is not suitable for drinking and for other domestic usage.

As Maldives is not an agricultural country, delayed onset of southwest monsoon (wet season) for a period of one month may not be considered as drought. But from the very olden times, Maldivians depend on rainwater for drinking and some domestic use. Therefore in addition to public water tanks provided by the government, most of the houses in the islands have their own mechanism for harvesting rainwater. If the dry season exceeds to a certain limit depending on the island's capacity of rainwater harvesting, many islands fall shortage of fresh water for drinking and other domestic use. With the modern development and increasing population, the demand for fresh water has increased dramatically in the recent years, hence many islands are now equipped with desalination plants to provide fresh water for the domestic and house hold use. Those islands without the desalination plants have a need to be supplied with fresh water by mobile plants.

References

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Drought Risk Management in Nepal

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Abstract
Nepal is exposed to various kinds of natural and human induced disasters. From long past, rapid onset disasters such as floods, landslides, hailstorms, insect infestation and animal epidemic as well as slow onset disasters such as drought, hot and cold waves and starvation have aggregated many of the agricultural lands, crops, livestock and ultimately farmers in the nation. In southern parts of the country particularly eastern and central Terai, much of the effect is occurred due to inundation, sand filling and river cutting. The western, mid and far western Terai is more vulnerable for droughts and cold waves. In mid hills, landslide has converted much of the arable land into deserts and hailstorms are common in western hills. Varieties of physiographic, geological, ecological and metrological factors contribute to the high level of hazard faced.

To cope with these phenomenon, farmers are using traditional methods such as terrace farming, planting horticultural crops in the pakho (slopes) and paddy and others in the khet (low irrigated land).Government particularly ministry of agriculture and cooperatives (MOAC) is expanding the knowledge of mitigating disaster up to farmers level by conducting various trainings and developing pamphlets and manuals about disaster in agriculture. MOAC is also conducting immediate, mid term as well as long term relief programs to raise the living standard of the affected farmers. The paper mainly focuses on the effect in household food security by drought.

Introduction

Nepal is located in between the latitude 26 22 North to 30 27 North and longitude 80 4 East to 88 12 East and elevation ranges from 90 to 8848 meters. The average length being 885 km east to west and average breadth is about 193 km north to south. The country is bordering between the two most populous countries of the world, India in the east, south, west and china in the north. Nepal is a landlocked country. The northern range (Himalaya) is covered with snow over the year. The middle range (Hill) is captured by mountains, high peaks, hills valleys and lakes. The southern range (Terai) is the plain of alluvial soil and consists of dense forest area and crop lands. The country is the residence of more than 100 caste ethnic groups. The temperature and rainfall differ from place to place. The population census 2001 reported about 23.1 million population, which is now, estimated around 28.3 million.

Nepal is a country exposed to several types of natural and human-induced hazards. A wide variety of physical, geological, ecological and meteorological factors contribute to the high level of hazard faced. Various demographic factors such as rapid population growth, improper land use, slow economic development and the conflict situation help increase population's vulnerability. Major types of hazards in Nepal include:

flood, earthquake, drought, hot and cold waves, landslide, hailstorm, disease epidemic, glacial lake outburst flood (GLOF), and fires. Among them, drought, floods and landslides are the most recurrent, causing yearly significant material and human loses in the country. Being a country prone to many frequent disasters, the awareness among the people and institutions is seriously lacking, which ultimately contributes to lack of preparedness and mitigation and finally to the high vulnerability. In regard to above, natural disasters might be considered as a key issue in the development process and poverty reduction of Nepal, not only in reference to the direct losses from infrastructure and assets destroyed during the disaster; but also due to the economical implications of reduced levels of production, linked to damage in productive assets and infrastructure, that as a result, limit the access to raw materials, food supply, energy, labor and markets

In light to above, we believe that the only way for coping with natural disasters is through activities that could decrease the risk of the populations exposed to the hazards; understanding risk as the probability of harmful consequences or expected loss, resulting from the interaction between natural or human induced hazards and vulnerable/capable conditions.

Definition of Natural Disaster:

According to the Natural Disaster Relief Act (NDRA), 1982 A.D. Natural Disaster means earthquake, fire, storm, flood, landslide, heavy rain, drought, famine, epidemic and other similar natural disaster. It also includes the industrial incident or accident caused by explosions of poisoning and any other kinds of disaster.

The Act defines Natural Disaster Relief Work as any relief work to be carried out in the area affected or likely to be affected by the natural disaster in order to remove the grief and inconvenience caused to the people, to rehabilitate the victims of the natural disaster, to protect the public property and life and property of the people, to control and prevent the natural disaster and to make advance preparation thereof.

Types of Major Natural Disasters

Brief descriptions of some major natural disasters which occur frequently in Nepal are given below:

1. Earthquake

The seismic record of Nepal goes back to 1255 A.D. Since then a series of destructive earthquakes occurred in 1408 A.D., 1681 A.D., 1810 A.D., 1833 A. D. and 1866 A.D. Among all these earthquakes, the event of 1833 A.D. was the major one. Exact data of that event are not available. After that Nepal passed through a very big earthquake in 1934 A.D. with a tremor of 8.4 Richter scale magnitudes. Kathmandu was the epicentre of the quake. The quake claimed the life of 16,875 people. Nepal experienced two other major earthquakes one in 1980 A.D. and another in 1988 A.D. The earthquake of 1988 A.D. had a tremor of 6.6 Richter scale with the epicentre in Udayapur district.

2. Flood, Landslide and Debris Flow

There are more than 6000 rivers and streams in Nepal. Most of them flow from the north towards the south, generally with high velocity due to high river gradient. Most of the big rivers are snow fed which originate from the Himalayan range that is covered by perpetual snow. As the topography of the country is steep, rugged and high-angle slope with complex geology, very high intensity of rainfall during the monsoon season causes flood, landslide and debris flow. The landslide and flood are the most destructive types of disasters in Nepal. Three quarter of the total land area of Nepal is hilly and many villages are situated on or adjacent to the unstable hill slopes. As a result, landslide and flood with debris flow occurs. Unplanned settlements and physical constructions without due consideration to the natural hazards are considerably aggravating the mountain environment. On the other hand the landslide add enormous load to the streams and rivers causing flood and debris flow downstream. Each year such types of disasters cause the losses of a number of human life and immense damages to agricultural land, crops, human settlements and other physical properties. In July 1993 A.D. Nepal experienced a devastating flood in the Tarai region of Nepal which took the life of 1336 people and affected 487,534 people. After 1993 A.D. 2004 A.D flood and landslide and Koshi Embankment caused flood of 2008 and late mansoon flood of Mid and Far west were severe which affected various lives and properties.

3. Fire

Fire disaster occurs mainly in the dry season between April to June. During this season the temperature in the Tarai region rises above 35° Celsius and it rains seldom. Fire disaster takes place mostly in the rural areas of the Tarai and the middle Hill region of Nepal. As 85.4 percent of the total population live in the rural areas in a very poor housing condition fire hazards are common. The houses of the rural areas especially of the Tarai areas are usually very close to each other and are made up of straw or reeds and timber which are easily caught by fire. The longest dry spell of winter 2009 caused heavy fires mainly in the forest land and this continued to this year as well.

4. Epidemic

In most cases the epidemic of cholera, gastro interitis, encephalitis, meningitis, typhoid, jaundice, malaria and so on occur during the summer and rainy season. This type of disaster occur mainly due to the lack of proper health care and sanitation. Last years Diarrhea epidemic in mid west region particularly in Jajarkot district caused about 1000 deaths.

5. Avalanche

As the northern part of the country is covered with snow peaks, avalanche is very common and sometimes it claims the life of human being as well. The avalanche at Khumbu and Kanchanjungha areas are much common.

6. Glacier Lake Outburst Flood (GLOF)

In the Himalayan region of Nepal glacier lakes are common. These lakes contain huge volume of water and remain in unstable condition, as a result, they can burst any time and a natural catastrophe may cause loss of life and physical property.

7. Windstorm, Thunderbolt and Hailstorm

Windstorm occur mainly during the dry season between March to May. Thunderbolt occurs during the monsoon and hailstorm takes place during the beginning and end of the monsoon. Hailstorm causes heavy losses of agricultural crops though human life loss is seldom. Windstorm and thunderbolt causes the loss of human life as well as physical property.

8. Drought

Some parts of the country face the problem of drought. Uneven and irregular monsoon rainfall is the main factor of drought in rainy season and low precipitation in winter is the factor of drought in the winter. The mountainous region (the northern belt) of Nepal is generally dry. The lack of irrigation facilities makes the problem even more serious as prolonged drought condition has adverse effect in agricultural production.

The prolonged drought in 2008/09 winter season has affected the winter crops mainly wheat and barley. The effect was so devastating that the production fell down to 17% at national level and up to 70% in some parts of the country.

Similarly late mansoon in 2009/10 has affected the major crop paddy and the decline was about 11% at national level.

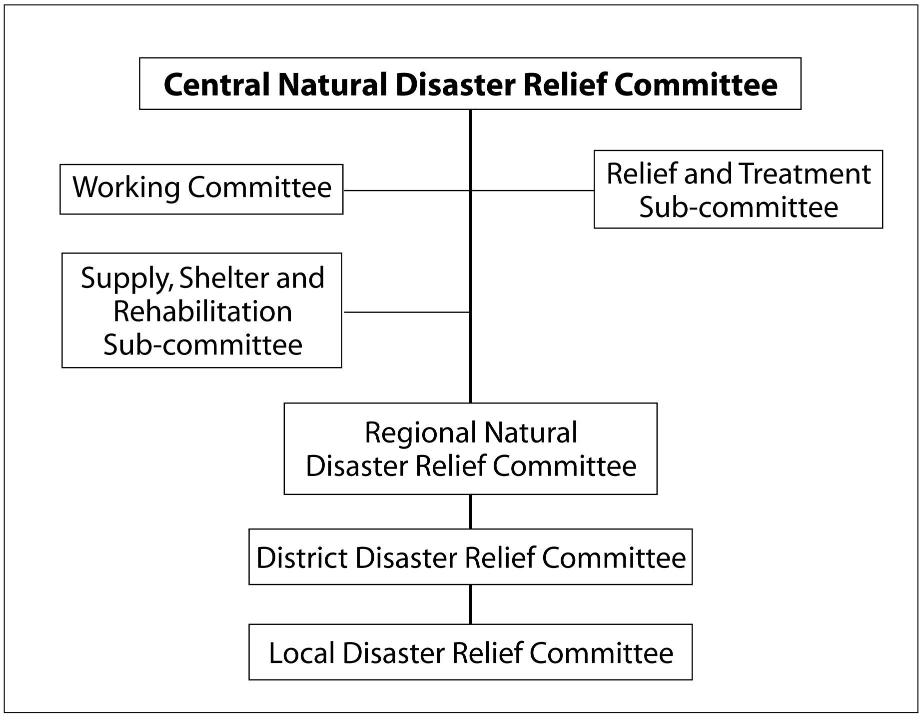
9. Cold wave

The newly emerging type of disaster is cold wave (sky overcast), which is frequently occurred in the Terai region of the country in winter season. An assessment of loss of winter crops by sky overcast is done by Nepal Agriculture Research Council and loss is devastating in some crops.

Current System of Drought Management in Nepal

Legal Status

- Natural disaster relief act, 1982 is enacted.
- MoHA is designated as the 'National Focal Point for DM'.
- Sectoral Ministries have been assigned as focal ministries for particular types of disast
- Organizational Chart :



National disaster act, policy, System etc which are directly or indirectly related with the drought risk management

- Natural Calamity Relief Act, 1982
- Three Years Interim Plan, 2007-2010
- Environmental protection act,1996
- Local Self-governance Act,1999 devolution of responsibility and authority for the local levels
- Institution Registration Act, 1977 (to establish NGO/CBO).
- National Action Plan, 1996(Revised)
- Disaster Victim Relief Distribution Standard, 2007
- In coordination and support of government, since 1996 UNDP, JICA and Nepal Red Cross have initiated the community-based disaster management (CBDM), First within SAARC countries.
- Commitment on WCDR (HFA), 2005-2015AD
- The Forestry Sector Policy 2000
- National strategy for disaster risk Management-2009 (NSDRM)
- Hyogo Framework for action 2005-2015
- National agriculture policy 2004.
- National shelter policy 1996.
- National urban policies 2006.
- Nepal living standard survey (identify the economically vulnerable segment of the society)
- Water resource policy, 1993
- DWIDP's working procedure-2007
- National Water Resource Strategy, 2002 – setting strategic targets for 5 years, 15 years and 25 years

- National Water Plan, 2005
- Water Induced Disaster Management Policy, 2006
- Nepal Land-use Policy
- Inclusion of disaster risk mitigation in decentralized planning process.
- Other Sect- oral Plan and Policies

New Institutional system by NSDRM

Sectoral strategy of NSDRM

- Agriculture
- Health
- Education
- Shelter, infrastructure, and physical planning
- Livelihood protection
- Water and sanitation
- Forest and soil conservation
- Information ,communication , coordination and logistics
- Search & rescue and damage/need assessment

Historical data on disaster in Agriculture

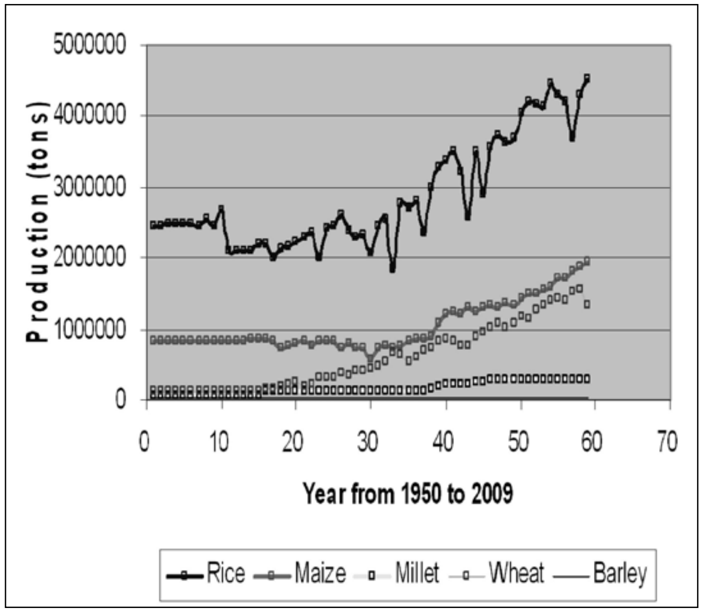
Ministry of Agriculture and Cooperatives have developed some formats for collecting information on losses by natural disasters mainly on crops and livestock and implementing them through district agricultural development and livestock services office. The table below highlights some major losses in agriculture sector by natural disasters in recent years.

S.No.	Description	Year								Remarks
		2002	2003	2004	2005	2006	2007	2008	2009	
1	Paddy	115000	6967	116505	3585	120000	88800	30873	92000	
2	Maize	4435	954	1293	20	47	4271	549	1700	
3	Millette			500	419	0	1451	3	0	
4	Others	2067	611							
5	Fish	985 ponds	14	41ponds						
6	Livestock	4700						1295		
	Main Reasons	Drought, Floods	Floods, Landslides	Drought, Floods, Landslides	Landslides	Floods, Drought	Drought, Floods, Landslides	Floods, Landslides	Floods, Drought	

***Source**: Bimonthly Bulletin of Crop and Livestock Situation, 2066,Mangsir/Poush various years. ABPSD, MOAC*

The data on above table shows the heterogeneous pattern on the effect on agricultural production by various types of disasters. The summer crops are mainly affected by floods, landslides, water logging and drought in some cases where as the winter crops are mostly affected by cold waves, hailstones and drought in most of the cases. Similarly the spring and off season crops are affected by drought, hailstones as well as insects and pests.

Cereal Crop Production over the years



The above chart shows the cereal crop production over last 60 years. The troughs in the graph are the effect of drought which could be seen on the various years; the latest one being of year 2008/09 as already explained.

Relationship between Drought and food security

The food security situation of country as well as a specific area is highly affected by various types of disasters. Some disasters particularly floods and water logging in short situations are affirmative to the production of rice. Since rice has the share of more than 50 percent in Nepalese food basket; the overall food security situation improves in case of heavy rains causing flood which also brings organic material with it. The other rapid onset disasters like hailstone, landslides are inversely related to food security situation but their scope is limited. The slow onset disasters particularly drought and cold waves are very very harmful to the crops causing severe loss in a relatively large area affecting the overall food security situation of the nation.

Food Balance Situation at National Level

Year	Prod.	Req.	Balance	SSR
1993/94	3585112	3723722	-138610	96
1994/95	3397760	3882915	-485155	88
1995/96	3913878	3948229	-34351	99
1996/97	3972587	4079135	-106548	97
1997/98	4027349	4178077	-150728	96
1998/99	4097612	4279491	-181879	96
1999/00	4451939	4383443	68496	102
2000/01	4513179	4424192	88987	102
2001/02	4543049	4463027	80022	102
2002/03	4653385	4619962	33423	101
2003/04	4884371	4671344	213027	105
2004/05	4942553	4779710	162843	103
2005/06	4869436	4890993	-21557	100
2006/07	4753340	4941089	-187749	96
2007/08	5195211	5172844	22367	100
2008/09	5160400	5293316	-132914	97
2009/10*	5097788	5413788	-316000	94

***Source**: ABPSD, MOAC, May 2010*

The total area of Nepal is 147181 square KM in which 2.64 million ha is agriculture land. Among that 1.76 million ha is irrigable and among that 1.22 million ha is irrigated. The irrigation is mainly surface irrigation and level of water mainly depends on the rainfall pattern.

The major irrigation projects and programs are handled by Ministry of Irrigation and small scale farmer managed irrigation facilities are also operated by Ministry of Agriculture and Cooperatives. The irrigation in the country is mainly surface irrigation and nowadays water harvesting, sprinkle irrigation, drop irrigation are also becoming popular within the farmers particularly small scale farmers for the cultivation of off season vegetables and spice crops.

TABLE 7
Present Level of Irrigation Development

DISTRICT	OVERALL TOTAL	TOTAL IRRIGABLE	SURFACE FMIS: AGENCIES ASSISTED				DOI SURFACE	TOTAL SURFACE	GROUNDWATER			NON-CONVENTIONAL	TOTAL IRRIGATED AREA (HA)
			NTW	RTH	NON-ASSISTED	TOTAL FMIS			STW	DTW	TOTAL		
Eastern Development Region													
Eastern Region Terai Ecological Belt													
Jhapa	109529	109530	4482	8553	46951	59986	8000	67986	20794.5	240	21034.5	1153	90174
Morang	102938	99959	996	15322	17068	33386	33500	66886	22155.5	270	22425.5	440	89752
Saptari	76949	76950	210	5665	1863	7738	36425	44163	11387	80	11467	168	55798
Siraha	77726	77726	1083	6150	3186	10419	14815	25234	13163.5	620	13783.5	89	39107
Sunsari	71757	70629	110	8171	557	8838	34500	43338	21612	40	21652	167	65157
Eastern Terai	**438899**	**434794**	**6881**	**43861**	**69625**	**120367**	**127240**	**247607**	**89112.5**	**1250**	**90362.5**	**2017**	**339987**
Eastern Region Hill Ecological Belt												0	
Bhojpur	34676	6820	810	1126	361	2297	0	2297	0	0	0	210	2507
Dhankuta	26797	7495	825	1986	2228	5039	0	5039	0	0	0	205	5244
Ilam	36405	12742	1381	3158	975	5514	0	5514	0	0	0	1338	6852
Khotang	37950	8859	1133	1764	1750	4647	200	4847	0	0	0	33	4880
Okhaldhunga	24151	4478	852	1187	1311	3350	240	3590	0	0	0	9	3599
Panchthar	32252	7241	956	1753	5337	8046	0	8046	0	0	0	647	8693
Terathum	21662	6282	972	1492	2253	4717	0	4717	0	0	0	215	4932
Udaypur	30773	18408	1136	1713	7969	10818	390	11208	674	0	674	91	11973
Eastern Hill	**244666**	**72325**	**8065**	**14179**	**22184**	**44428**	**830**	**45258**	**674**	**0**	**674**	**2748**	**48680**
Eastern Region Mountain Ecological Belt												0	
Sankhuwasabha	25972	5170	466	1877	3818	6161	0	6161	0	0	0	176	6337
Solukhumbu	17734	2038	164	977	2712	3853	0	3853	0	0	0	29	3882
Taplejung	22102	7443	1227	1454	4586	7267	0	7267	0	0	0	491	7758
Eastern Mountain	**65808**	**14651**	**1857**	**4308**	**11116**	**17281**	**0**	**17281**	**0**	**0**	**0**	**696**	**17977**
Eastern Region	**749373**	**521770**	**16803**	**62348**	**102925**	**182076**	**128070**	**310146**	**89786.5**	**1250**	**91036.5**	**5461**	**406643.5**
Central Development Region												0	
Central Region Terai Ecological Belt												0	
Bara	61766	60390	0	9820	8802	18622	13720	32342	21309	620	21929	54	54325
Chitwan	44537	41963	1009	14365	0	15374	10900	26274	3013	280	3293	56	29623
Dhanusha	72925	72925	1475	5700	8457	15632	14500	30132	11442	2790	14232	707	45071
Mahottari	60649	60633	888	3803	22253	26944	0	26944	7639	1288	8927	781	36652
Parsa	48374	48374	282	4992	2356	7630	16180	23810	5068	48	5116	128	29054
Rautahat	56390	56141	8	6318	1249	7575	33200	40775	13338	40	13378	55	54208
Sarlahi	73710	73521	2500	5582	15478	23560	28400	51960	16114.5	590	16704.5	73	68738
Central Terai	**418351**	**413947**	**6162**	**50580**	**58595**	**115337**	**116000**	**232237**	**77923.5**	**5656**	**83579.5**	**1854**	**317671**
Central Region Hill Ecological Belt												0	
Bhaktapur	7223	6274	181	2900	0	3081	1205	4286	0	0	0	33	4319
Dhading	36190	10839	1836	2182	3006	7024	360	7384	0	0	0	291	7675
Kathmandu	17104	14069	736	1826	0	2562	2130	4692	0	0	0	437	5129
Kavre	29921	7958	936	2833	402	4171	0	4171	0	0	0	207	4378
Lalitpur	11068	7425	0	3467	0	3467	1410	4877	0	0	0	47	4924
Makawanpur	35776	23502	931	2093	222	3246	0	3246	53	0	53	34	3333
Nuwakot	31783	15047	1851	2971	380	5202	1172	6374	0	0	0	33	6407
Ramechap	32276	4248	1264	1688	2434	5386	0	5386	0	0	0	1	5387
Sindhuli	34333	20652	1364	2181	7119	10664	60	10724	4	0	4	0	10728
Central Hill	**235674**	**110014**	**9099**	**22141**	**13563**	**44803**	**6337**	**51140**	**57**	**0**	**57**	**1083**	**52280**
Central Region Mountain Ecological Belt												0	
Dolakha	24042	4911	1127	1464	2311	4902	175	5077	0	0	0	124	5201
Rasuwa	5201	836	539	411	675	1625	0	1625	0	0	0	8	1633
Sindhupalchowk	33820	12276	1834	3017	3069	7920	0	7920	0	0	0	84	8004
Central Mountain	**63063**	**18023**	**3500**	**4892**	**6055**	**14447**	**175**	**14622**	**0**	**0**	**0**	**216**	**14838**
Central Region	**717088**	**541984**	**18761**	**77613**	**78213**	**174587**	**123412**	**297999**	**77980.5**	**5656**	**83636.5**	**3153**	**384788.5**
Western Development Region												0	
Western Region Terai Ecological Belt												0	
Kapilvastu	84785	84453	337	7992	12412	20741	6900	27641	2796	1600	4396	71	32108
Nawalparasi	55238	50690	191	6770	12220	19181	13830	33011	6083	1160	7243	79	40333
Rupandehi	88416	87979	15	17142	18437	35594	7300	42894	14912	20909	35821	173	78888
Western Terai	**228439**	**223122**	**543**	**31904**	**43069**	**75516**	**28030**	**103546**	**23791**	**23669**	**47460**	**322.88**	**151329**
Western Region Hill Ecological Belt												0	
Arghakhanchi	20020	4799	50	1732	654	2436	0	2436	0	0	0	415	2851
Baglung	26522	7780	293	1278	190	1761	0	1761	0	0	0	149	1910
Gorkha	33914	11027	147	2535	711	3393	489	3882	0	0	0	118	4000
Gulmi	25606	4240	111	1913	0	2024	160	2184	0	0	0	370	2554
Kaski	31405	15960	36	2879	4044	6959	3740	10699	0	0	0	89	10788
Lamjung	23848	11937	107	3988	0	4095	714	4809	0	0	0	128	4937
Myagdi	15740	3685	185	1354	98	1637	0	1637	0	0	0	90	1727
Palpa	30354	8857	14	2136	1231	3381	282	3663	0	0	0	333	3996
Parbat	15231	6455	200	2743	118	3061	425	3486	0	0	0	49	3535
Syangja	31018	9848	22	3989	0	4011	0	4011	0	0	0	45	4056
Tanahu	33972	14406	20	2658	0	2678	790	3468	1		1	174	3643
Western Hill	**287630**	**99084**	**1185**	**27206**	**7016**	**35436**	**6600**	**42036**	**1**	**0**	**1**	**1960.35**	**43997**
Western Region Mountain Ecological Belt												0	
Manang	718	121	0	348	0	348	0	348	0	0	0	0	348
Mustang	4221	159	55	1015	263	1333	51	1384	0	0	0	2	1386
Western Mountain	**4939**	**280**	**55**	**1363**	**263**	**1681**	**51**	**1732**	**0**	**0**	**0**	**2**	**1734**
Western Region	**521008**	**322486**	**1783**	**60472**	**50378**	**112633**	**34681**	**147314**	**23792**	**23669**	**47461**	**2285.23**	**197060.23**
Mid-Western Development Region												0	
Mid-Western Region Terai Ecological Belt												0	
Banke	49525	48550	0	4460	1669	6129	1250	7379	8173	2380	10553	320	18252
Bardiya	52836	52660	0	31918	0	31918	960	32878	7835	600	8435	152	41465
Dang	64522	59505	192	17960	13756	31908	2585	34493	2848	1675	4523	288	39304
Mid-Western Terai	**166883**	**160715**	**192**	**54338**	**15425**	**69955**	**4795**	**74750**	**18856**	**4655**	**23511**	**760**	**99021**
Mid-Western Region Hill Ecological Belt												0	
Dailekh	28373	7075	61	840	1957	2858	0	2858	0	0	0	27	2885
Jajarkot	21114	4143	150	949	350	1449	0	1449	0	0	0	10	1459
Pyuthan	23197	7037	0	1257	2476	3733	340	4073	0	0	0	9	4082
Rolpa	29651	3080	0	1011	0	1011	0	1011	0	0	0	36	1047
Rukum	23592	4170	15	1344	41	1400	600	2000	0	0	0	37	2037
Salyan	28033	5282	0	1356	1440	2796	0	2796	0	0	0	40	2836
Surkhet	31231	19275	513	4620	5242	10375	387	10762	0	0	0	125	10887
Mid-Western Hill	**185191**	**50962**	**739**	**11377**	**11506**	**23622**	**1327**	**24949**	**0**	**0**	**0**	**283.95**	**25233**
Mid-Western Region Mountain Ecological Belt												0	
Dolpa	4996	544	77	534	546	1157	0	1157	0	0	0	21	1178
Humla	4983	969	0	575	0	575	0	575	0	0	0	7	582
Jumla	12642	4765	0	588	1006	1594	0	1594	0	0	0	13	1607
Kalikot	13126	3084	0	1483	240	1723	0	1723	0	0	0	4	1727
Mugu	9616	2030	0	235	735	970	0	970	0	0	0	0	970
Mid-Western Mountain	**45363**	**11392**	**77**	**3415**	**2527**	**6019**	**0**	**6019**	**0**	**0**	**0**	**45**	**6064**
Mid-Western Region	**397437**	**223069**	**1008**	**69130**	**29458**	**99596**	**6122**	**105718**	**18856**	**4655**	**23511**	**1088.95**	**130318**
Far-Western Development Region												0	
Far-Western Region Terai Ecological Belt												0	
Kailali	66723	64112	0	13334	15688	29022	7133	36155	18724	1840	20564	263	56982
Kanchanpur	40970	40891	103	3614	2270	5987	11600	17587	10919	1030	11949	472	30008
Far-Western Terai	**107693**	**105003**	**103**	**16948**	**17958**	**35009**	**18733**	**53742**	**29643**	**2870**	**32513**	**735**	**86990**
Far-Western Region Hill Ecological Belt												0	
Achham	31982	10972	133	1267	1099	2499	871	3370	0	0	0	1	3371
Baitadi	25543	7450	80	2296	0	2236	395	2631	0	0	0	223	2854
Dadeldhura	16032	7266	7	2730	0	2737	0	2737	0	0	0	27	2764
Doti	27562	10468	0	1969	554	2523	603	3126	0	0	0	9	3135
Far-Western Hill	**101119**	**36156**	**170**	**8172**	**1653**	**9995**	**1869**	**11864**	**0**	**0**	**0**	**259.84**	**12124**
Far-Western Region Mountain Ecological Belt												0	
Bajhang	22642	7549	0	1049	643	1692	1354	3046	0	0	0	4	3050
Bajura	12181	3584	0	655	3120	3775	280	4055	0	0	0	0	4055
Darchula	13201	4239	22	2278	0	2300	0	2300	0	0	0	24	2324
Far-Western Mountain	**48024**	**15372**	**22**	**3982**	**3763**	**7767**	**1634**	**9401**	**0**	**0**	**0**	**28**	**9429**
Far-Western Region	**256836**	**156531**	**295**	**29102**	**23374**	**52771**	**22236**	**75007**	**29643**	**2870**	**32513**	**1022.84**	**108542.84**
Total	**2641742**	**1765840**	**38650**	**298665**	**284348**	**621663**	**314521**	**936184**	**240058**	**38100**	**278158**	**13011.12**	**1227353.02**

***Source**: Department of Irrigation, GON, 2008/09*

Problems in Drought Risk Management in Nepal

Drought management is a difficult task. Though it is a slow onset disaster by nature but the effect, especially during a very serious drought, it becomes very difficult to cope with a normal set up and limited funds and resources. In view of the above situation Nepal is facing a number of severe problems like : poor public awareness, low literacy rate, mass poverty, fatalistic nature of some people, difficult and undeveloped physical infrastructure, unplanned settlement, lack of political commitment, slow decision making process and so on. Apart from the above the lack of cooperation and coordination among various disaster management related agencies and their behavior indifference, duplication of relief works, inadequate funds and resources and the lack of modern technology especially early warning system have made the disaster as well as drought situation more complex.

Measures to Solve the Problems

Despite of the various problems, appropriate policy measures could help to solve the problems. As public awareness is one of the vital problems in managing the drought disaster and obtaining the food security situation in Nepal, it is felt necessary to work at increasing the coping capacity. To attain all this, there is the need of the strong political determination, pragmatic policy formulation and quick decision making. Moreover, active people's participation is also very necessary. On the other hand it will be better to include drought risk management component in the agriculture and irrigation development plans and programs of concerned agencies particularly Ministry of Agriculture and Cooperatives, Ministry of Irrigation for the effective implementation of drought risk reduction programs and achieving the food secure nation.

Conclusion:

Not only in Nepal, hydro meteorological disasters happen almost all over the world causing heavy loss of human life, destruction of infrastructure and properties and drought mainly causing crops and livestock etc . Usually natural disasters can not be stopped but effect of natural calamities can be reduced if it is known in advance. However, the magnitude of disasters can be reduced if preventive measures be taken in due time for which pragmatic government policies and public awareness are of utmost importance. This is especially true if the government, community and the people work together to this end. The effects of natural disasters particularly drought on daily food basket are vital but could be reduced with the efforts of government, community and the people as well.

Drought Risk Management has not been given due importance at the national level and should be given priority for the benefit of marginal farmers, general people as consumers and national economy.

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Drought Mitigation in Pakistan: Current Status and Options for Future Strategies

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Introduction

Droughts are some of the most complex natural disasters, and are difficult to predict and mitigate due to a number of factors involved, lack of precise information on many drought-related issues, difficulties in defining a drought (its start, end and magnitude), etc. The spatial and temporal characterization and assessment of a drought are only meaningful if they are integrated with the socioeconomic indicators. The lack of integrating socioeconomics with the hydrometeorology of droughts is one major limitation of the work already done in this area. The other important aspect is that a drought must be seen from the end of impacts and mitigation measures while developing drought-characterization-assessment approaches. These impacts will also vary in space and time due to regional variability.

Droughts are typical in Pakistan as in most of southwest Asia and continue to cause multiple adverse impacts. To design successful anti-drought measures, the current state of the art in drought assessment and management in countries of the region must be first critically analyzed and gaps identified. This study is a part of the Regional Project on "Drought Assessment and Potential for Mitigation in Southwest Asia," being implemented by IWMI in collaboration with partners in the region. The project is funded by the US Department of State, and has a focus on Afghanistan, India and Pakistan. The entire project is designed to examine the multiplicity of drought-related issues in the region and is intended as a "survey," to prepare the ground for a large-scale drought research and action program in the countries of the region. This particular study is aimed to review the current status of drought-related issues and measures in Pakistan. It is also supplemented by the socio-economic survey, conducted jointly by IWMI and Pakistan Agricultural Research Council (PARC) in the provinces of Sindh and Baluchistan (the results of the survey are presented in a different report).

The Baluchistan and Sindh provinces are selected as target areas in Pakistan, as a start, but the study also addresses issues of national importance. This paper reviews factors affecting or associated with droughts, focusing on the target areas, identifying gaps in the institutional and policy arenas with recommendations for remedial measures, providing analyses of coping strategies adopted by various stakeholders in mitigating droughts, and documenting lessons gained during previous drought cycles.

More specifically, the study focuses on two groups of issues: technological interventions to combat droughts and institutional arrangements and policies for managing droughts in Pakistan. The first group includes issues like traditional water-conservation methods in target areas and their effectiveness during droughts, new technological measures proposed and the extent of their implementation, prospects for such interventions in target areas for the future in the short and long-term, etc.

The second group deals with issues like the state of the art of drought-monitoring in Pakistan, processes of drought declaration and links with relief plans, institutional responsibilities for all of the above, gaps in institutional and policy aspects in drought management at present, etc.

It is envisaged that the results of the Pakistan study would be of interest to the federal and provincial governments to further focus their drought-mitigation activities in the country. The results would also be helpful for the planners and policymakers for identifying the future program of action related to drought-mitigation and -relief programs.

Target Areas

Baluchistan

The geographical area of Baluchistan is around 347,190 km2 and it is the largest province of Pakistan constituting about 44% of the country's geographical area. According to the 1998 Census, the population of the province is around 6.51 million (GOP 2002). The population is sparsely distributed, with its density around 19 persons per km2. Around 78% of the population lives in the rural areas. The climate largely ranges from semi-arid to hyperarid and temperature regimes vary widely from cool, temperate to tropical. Cold winters and mild summers characterize the northern highlands. Most of the precipitation is received in winter ranging from 250 to 350 mm. In the southwestern desert, the annual rainfall ranges from 50 to 125 mm and summers are hottest, with temperature occasionally rising above 50 °C. Annual evaporation rates are very high, exceeding 3,000 mm.

Agriculture and livestock production are the two dominant sectors contributing to the Baluchistan economy, accounting for over 50% of the provincial GDP and employing roughly 67% of the labor force (GOP 2003). The limited precipitation and availability of surface water drastically restricted the cultivated land to around 2.1 million hectares (Mha) during 2000-2001, which is around 6% of the province's geographical area. About 47% of the cultivated area is irrigated, while the remaining 53% is under sailaba (floodwater) and khushkhaba (rainfall and localized runoff) farming systems (GOP 2002). Although irrigated crop production plays a dominant role in the agricultural economy of Baluchistan, sailaba and khushkaba farming systems contribute to the livelihood of a sizeable majority of the population, regarded as the poorest of the poor. These two farming systems are dependent on precipitation and runoff and their performance also fluctuates drastically with the variations in precipitation and runoff. Without runoff, economical harvests are not possible due to low precipitation.

The wide agro-ecological diversity of Baluchistan permits cultivation of a wide range of field crops and horticulture. Although the province is a net importer of wheat, traditionally cereal production (wheat, rice, barley, sorghum and millet) has remained important to its economy, covering 70% of the cropped area and contributing 50% to the gross value of crops (GOP 2002). Besides, it serves as an important source of fodder for the livestock. The high altitude arid environments provide an ideal condition for the production of deciduous fruits. Baluchistan's share of deciduous fruits (apples, plums, pears, apricots, peaches and pomegranates) and nondeciduous fruits (dates) ranges from 35 to 85% of Pakistan's production. In the case of grapes, almonds and cumin, the province has an exclusive monopoly in the country.

Irrigated agriculture is dependent both on surface water and groundwater resources. The Khirthar and Pat Feeder canals of the Indus basin system and Lasbella canal feed the major area under irrigated agriculture from the Hub dam. Another important source of surface water is the floodwater that flows through the streams. Around 30% of the floodwater is harnessed for agriculture through sailaba diversions, storage dams and minor perennial irrigation schemes. The groundwater resource is available for irrigated agriculture through karezes, springs and wells. With the availability of electricity from the national grid, there has been a tremendous increase in the number of tube wells. Indiscriminate installation of tube wells and pumping of water in excess of recharge have caused lowering of the water table resulting in the drying of dug-wells and a number of karezes and springs.

The mining of groundwater and lowering of the water table are causing serious concern regarding sustainability of groundwater-irrigated agriculture.

Baluchistan's important economic activity is livestock production, which is one of the major sources of livelihood for around 70% of the rural population. Around 92% of the geographical area of the province has been categorized as rangelands, which provide grazing to around 20 million of the small ruminants (sheep and goats). Three livestock production systems are prevalent in the province: a) a small percentage of the agro-pastoralists is sedentary, they grow crops and maintain livestock and often have access to fodder and crop residues; b) a large proportion of livestock owners are transhumant, who commute between winter and summer quarters to adjust to the seasonal feed requirements; they also grow rain-fed crops; c) about 50% of the livestock owners are nomadic and constantly move between highlands and plains and sometimes cross international borders; they are entirely dependent on livestock for their livelihood, which is earned through trading of livestock and livestock products. Livestock marketing is often through middlemen and is highly exploitative. Livestock health services are provided by the Livestock Department through veterinary hospitals, dispensaries and mobile units but in several districts these are grossly inadequate.

Sindh

The geographical area of the Sindh province is around 140, 914 km2 and the population is over 30 million. Around 13% of the geographical area is under irrigated agriculture by perennial and nonperennial canals from the Indus basin. Salinity and waterlogging affect about half the irrigated area. The inefficient irrigation system and slow movement of water in the Indus river, due to the low gradient towards the sea, encourage percolation and cause waterlogging. In over two-thirds of the area of canal-irrigated agriculture, the groundwater is brackish.

The Thar region of the Sindh province is a large desert with sub-Saharan conditions and comprises 20,000 km2. Runoff agriculture and livestock production are the primary means of subsistence in this area. Annual rainfall in a wet year ranges between 200 and 250 mm and occurs mostly during the monsoonal season. The incident of rainfall and runoff in a wet year permits growing of millet as the main food crop. Guar is the main cash crop. It also supports growth of a range of grasses providing feed resource to the livestock throughout the year. It also recharges the thin fresh groundwater layer and provides opportunities for collection of surface runoff in earthen ponds. Lack or absence of rainfall during the monsoonal season results in acute shortage of food and fodder. People search for alternative sources for their livelihood, usually migrating to the periphery of the canal commands for seeking labor and taking loans from informal institutions for subsistence. Normally, these loans are available on high interest rates.

The Kohistan area of the province is extending along the west and northwestern border of the province, which is mountainous and is also dependent on runoff for farming of crops (millet, sorghum, mungbean and guar) and production of livestock (both large and small ruminants). Rainfall in these areas is scanty ranging from 100 to 120 mm and is highly erratic. The Kachho area lying between irrigated plains and the Kohistan belt is also dependent on rainfall in the ctachment areas, and failure of runoff affects the livelihood of people. However, the farmers have developed ways to find the shallow groundwater and increase yield even in areas having very little recharge through the installation of horizontal galleries.

The vast arid lands in both provinces with no source of canal irrigation and low precipitation offer little scope for perennial-irrigated agriculture. However, these areas are highly suitable for traditional farming systems (sailaba and khushkhaba) and livestock production, particularly small ruminants, cattle and camel. These animals are well adapted to the harsh environments and utilize available range resources efficiently.

Droughts and Their Impacts in Pakistan

A Country-Wide Perspective

Pakistan frequently experiences several droughts. The Punjab province underwent the worst droughts in 1899, 1920 and 1935. The North-West Frontier Province (NWFP) experienced such droughts in 1902 and 1951, while Sindh had its worst droughts in 1871, 1881, 1899, 1931, 1947 and 1999. The most severe droughts at the national scale were perhaps the most recent which occurred in 1999-2000 prolonging up to 2002 in certain areas. The rainfall is erratic and river flows have dropped. The water in the Tarbela dam reaches dead level in late February or early March almost every year. The current live reservoir capacity in the Indus basin has been reduced due to siltation. The recent drought has also exposed the vulnerability of the Indus basin irrigation system and environmental issues in deltaic areas.

Agricultural growth suffered a severe setback during 2000-2001 as a result of the drought. While major crops (wheat, cotton and rice) registered a negative growth of almost 10%, the overall agriculture recorded a negative growth of 2.6% during 2000-2001. The performance of minor crops (cereals, vegetables, fruits, condiments, oil seeds, fodder and others) was also affected by the prevalent long dry spell. The drought persisted throughout 2001-2002, resulting in water shortage of up to 51% of normal supplies as against 40% of the previous year. The total flows of water in major rivers also declined to 109 billion m3 against an average of 162 billion m3. Rainfall has also been below normal. The canal-head withdrawals in kharif '2001 and rabi 2001-2002 seasons have also witnessed a significant decline. Notwithstanding severe water shortages, the farmers in Pakistan have undertaken various measures to minimize their adverse effects. These include the judicious use of water, exploitation of groundwater, purchase of water from tube wells, improvements in cultural practices and better overall management. As a result, overall agriculture registered a positive growth of 1.4% in 2001-2002 as against a decline of 2.6% during 2000-2001 (Ahmad et al. 2003).

Drought also affected the performance of nonagricultural sectors. Pakistan's nonagricultural GDP growth remained stable at around 4.3% in 2001-2002 (table 1). Therefore, when adjusted for drought impact, the real GDP is provisionally estimated to grow by 4.7% against 5.2% in 2000-2001. The slower growth in real GDP over these 2 years was caused by drought. Had there been no drought, Pakistan's economic growth would have been around 5% (Ahmad et al. 2003).

Table 1: *Real GDP growth with and without drought (%).*

Sector	1999-2000	2000-2001	2001-2002
Real GDP	3.9	2.5	3.6
Nonagricultural GDP	3.1	4.2	4.3
Real GDP growth adjusted for drought impact	4.0	5.2	4.7

Note: *The real GDP growth is calculated by excluding value added in agriculture and electricity and gas distribution.*

The Government of Pakistan has implemented a relief program for the drought-affected areas with the objective of mitigating the effects of drought on the livelihood of rural communities. The major difficulty faced in the launching of a need-based project is the development or assessment of criteria, which is in line with the requirement of the affected areas. In 2001 the Planning and Development Division assigned the task to develop drought characterization and classification criteria to a number of institutions, and for this purpose the same task was assigned to the WRRI-NARC (WRRI 2001). Two characterization criteria were used by WRRI (2001).

Aridity index is a ratio of 50% probability of rainfall and the crop evapotranspiration. Based on the aridity index, aridity classes were categorized considering humid, subhumid, semiarid, arid and hyperarid agro-climates. The GIS software Arc Info was used for database development and spatial analysis. Based on the aridity, four classes of drought-prone areas—severe, high, moderate and low—were identified. The drought-prone districts were classified based on the aridity index of each district (figure 1). Another criterion, percent households having access to piped water supply was used to further characterize the drought-prone districts. In terms of both criteria, the Baluchistan and parts of Sindh provinces were ranked as "severely affected."
Figure 1. Drought-prone areas of Pakistan characterized, based on aridity index.

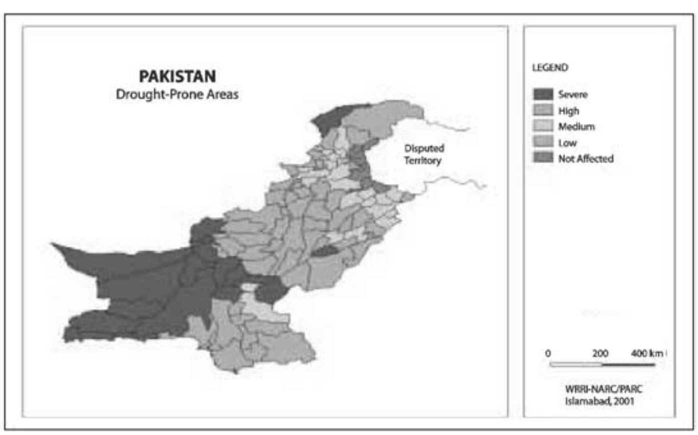

Figure 1 *: Drought-prone areas of Pakistan characterized, based on aridity index*

Impacts of the Recent Drought in Baluchistan and Sindh Provinces

Droughts in the Sindh and Baluchistan provinces have always been part of life, but they have increased in recent years. Both provinces suffered from the recent severe drought of 1998-2002, which affected the human/livestock population, crops and water resources. The drought resulted from the continuous lack of rainfall. In most severely affected areas, not a single drop of water was received during 1998-2002. In the Baluchistan province as a whole, the winter rains were reduced by 60 to 73% in some years. The situation is particularly serious in areas where groundwater is either deep or brackish and no surface-water resource is available. Other factors that increase the adverse impact of droughts include overexploitation of groundwater in violation of groundwater regulations, deforestation, depletion of grazing pastures due to lack of management, poor farm water management and lack of controlled cropping patterns (Ahmad et al. 2003).

In the Thar region of Sindh province, rains were down to only 30% (60 mm) and 12% (24 mm) of normal, during the years 1999 and 2000, respectively. Further, it was received in one storm and did not contribute to crop production and germination of range grasses. Other drought-affected, areas of Sindh—Mirpur Khas, Sanghar, Dadu and Thatta—received no rains during the last 5 to 6 years, totally eliminating rain-fed crop production, and livestock sustaining on rangeland vegetation, the two primary means of subsistence in these areas.

The latest drought in Sindh and Baluchistan is estimated to have affected over 3.3 million people, including thousands who became refugees and hundreds who died of thirst and starvation. It was also reported that about 30 million livestock were affected, including over 2 million that died. An emergency relief plan, involving an amount of about US$28 million, was carried out as part of the disaster-mitigation effort. Measures were adopted to strengthen logistics support, provide drinking water and material supplies to the drought-hit areas, medical cover to the affected population and treatment to endangered cattle. Food and fodder were also distributed (GOP 2001; Ahmad et al. 2003). The government has also taken up short- and long-term measures for continued supply of water to the drought-prone areas. The short-term measures include projects for groundwater recharge of Quetta, Pishin, Mastung and Mangochar valleys. Various long-term measures such as construction of small-scale storage reservoirs are also planned (Ahmad et al. 2003). Some drought impacts in the two provinces are briefly reviewed below.

Water Resources

In Baluchistan province, overexploitation of the groundwater resource, through tube wells, has caused an alarming rate of depletion of the water table in the Lora-Pashin, Nari river and Zoab basins. The extended drought preventing any recharge to the aquifer has further aggravated the situation in these overdrawn basins. Lowering of the water table has resulted in drying up of dug-wells, particularly in the uplands and 70% percent of the karezes (traditional water-harvesting and delivery systems) and natural springs. Karezes and springs, which are still alive, are running at only 1/2 to 1/3 of their capacities, with a drastic reduction in their command area. Lowering of the water table has also caused drying up of tube wells in several areas or reducing their discharge by up to 50%. Tube wells with diesel engines had to be abandoned because of their inability to pump water beyond a certain depth. Stream flows available for traditional sailaba cultivation (see next section for details) has either totally dried up or drastically reduced because there was no rainfall (FAO/WFP 2000a, b).

In the Sindh province, failure of rainfall and reduced flow of water in rivers and canals have affected groundwater recharge resulting in lowering of the water table, which had a positive impact on the productivity of irrigated agriculture due to waterlogging in the pre-drought situation. The surface wells in nonirrigated areas have dried and at some places the tube wells have also gone out of commission. The earthquake that hit areas in Badin and Tharparker districts in 2000 has also resulted in lowering of the water table from about 50 m to 150 m. Reduced stream flows have particularly affected the adjacent dug-wells, creating serious problems of availability of drinking water for human beings, as well as for livestock. Reduced recharge has also increased the salinity of groundwater. There was an overall shortage of 30 to 40% in the water flows of the Indus basin canals further multiplying the negative effects of drought. Reduced supply of canal water has resulted in a substantial reduction in cropped area of major crops and productivity (FAO/WFP 2000b; 2002a).

Crops

In the most severely drought-affected areas of Baluchistan, khushkhaba and sailaba farming (see next section for details) has totally disappeared. In areas severely or moderately affected by drought, crop areas have been reduced by 60 to 80% with productivity loss by almost 50%. Millet, sorghum, mungbean, guar and castor bean have been the traditional kharif crops while barley; rape and mustard have been the rabi crops. In addition to producing grains for human consumption or sale, these crops have been the primary source of stalks/crop residues for livestock feeding. A reduction to the extent of 87% has occurred in cropped area between 1995-1996 and 2000-2001. The area under wheat, barley and sorghum has registered drastic reductions of 84%, 96% and 95%, respectively (table 2).

Table 2 *: Areas of selected crops under sailaba and khushkhaba farming in Baluchistan.*

Year	Total cropped area (ha)	Area under major crops (ha)			
		Wheat	Barley	Rape and mustard	Sorghum
1995-1996	257,110	133,090	21,105	10,723	44,675
1996-1997	99,593	42,180	14,498	4,820	7,549
1998-1999	90,759	46,835	8,197	3,908	4,350
1999-2000	35,934	17,908	1,318	588	4,300
2000-2001	33,529	23,000	824	1,080	3,623
2001-2002	32,743	21,306	775	4,489	2,280

Due to the drying up of a large number of karezes and natural springs and reduced discharge from the tube wells, the cropped area served by wells has also been reduced by 15 to 20% and the yields have been reduced to the tune of 25 to 30% (FAO/WFP 2000a; 2002a, b).

According to a recent survey by the Department of Agriculture, about 40% apple, peach and apricot orchards in upland Baluchistan, have dried, cut and sold as fuel during 2000-2002. Orchards that have survived are producing 30 to 40% less fruit of low quality because of reduced availability of water for irrigation. Rain-fed and irrigated fodder production has decreased considerably. This, coupled with a drastic reduction in the productivity of range grasses, has created problems for the sustenance of livestock even in reduced numbers.

Trends of substitution of low-water deltaic crops like cotton and cumin in place of high-water deltaic crops like onion in Kharan, Chaghi, Lasbella and Panjgur were observed. The need for training of both the farmers and the extension staff of the Agriculture Department, in production management of a new crop like cotton, was evident (FAO/WFP 2000a; 2002b).

Drought also increased the soil salinity in several areas because of reduced leaching of salts and more evapo-transpiration. The increased salinity has had adverse effects on crop yields. Because of the continuous dry weather there was increased wind erosion of surface soil. Farm operations jobs have reduced by almost 60% adding to unemployment. There was an increased incidence of pests and diseases. Drought, coupled with pest infestation, has threatened the date palm economy.

In the province of Sindh, the sailaba farming in drought-affected areas of Dadu, Thatta and Mirpur Khas districts has been completely eroded due to failure of rains during 5 years. In the Tharparkar district, moderate monsoonal rains in 2001 enabled planting of rain-fed crops, though yields were much below normal. The year 2002 went almost dry in Tharparkar with no crop production. Carryover stalks of sorghum and millet from the summer of 2001 helped in sustaining the livestock during the first half of 2002 but, later, the flock owners had to migrate to the canal commands (FAO AVFP 2000b; 2002a).

Reduced water supply in the Indus basin canal system has caused major reductions in area and production of major crops. The combination of drought and reduced irrigation water supply had a negative effect on crop production. Reductions in area during 2000-2001 and 2001-2002, in comparison with 1998-1999, have ranged from 11.1 to 54.3% and those in production from 12.8 to 55.0%. Reductions are particularly high in rice, millet and kharif fodder (table 3). This drop in crop production in the irrigated areas has reduced their capacity to support the migrant stockowners from the Thar desert by providing employment and crop residues to feed their livestock.

Table 3 *: Area* and production** of major crops in Sindh.*

Crop	1998-99		2000-2001				2001-2002			
	Area	Prod	Area	Prod	% charge over 1998-1999		Area	Prod	% chan ge over 1998-1999	
					Area	Prod			Area	Prod
Wheat	1124	2675	811	2226	-28	-17	875	2101	-22	-22
Rice	704	1930	540	1682	-23	-13	461	1159	-35	-40
Sugarcane	271	17051	239	12050	-12	-29	241	11416	-11	-33
Cotton	630	2134	524	2141	-17	0	547	2443	-13	15
Sorghum	110	64	87	52	-21	-19	89	57	-19	-11
Millet	175	73	80	41	-54	-44	100	54	-43	-26
Fodder-R	196	3069	109	1382	-45	-55	145	1956	-22	-35
Fodder-K	205	6741	178	5878	-14	-13	153	5372	-25	-20

** Area is '000 ha*
*** Production of cotton in '000 bales, all others in '000 mt.*

Reduced aquifer recharge and consequent lowering of the water table have increased salinity of the groundwater making it hazardous for human and livestock consumption. At places, the salt contents of groundwater were reported to have increased from less than 1,000 ppm to over 2,000 ppm (FAO/WFP 2002a). The data collected by WRRI indicated that, in certain areas, the salinity of groundwater was as high as 6,000 ppm due to seawater intrusion.

Rangelands of Baluchistan (91% of the total geographical area) have traditionally supported over 20 million of livestock. Over the years, these rangelands have degraded due to overgrazing and fuelwood extraction. The influx of a large number of Afghan refugees, along with their livestock had put added pressure on grazing lands. The persistent 5-year drought has further aggravated the situation resulting in severe damage to net productivity of rangelands, dropping from 60 kg/ha to 18 kg/ha. Vast areas have been denuded and the carrying capacity of these rangelands has reduced considerably. The flock owners were forced to sell their stock at prices up to 5 times lower compared to the pre-drought prices. Mortality due to hunger and disease infestation of malnourished animals has increased severalfold. Distress sale and mortality together have resulted in an overall reduction of 35% in stock size, with the individual owners in most severely affected areas losing 80-100% of their animals (FAO/WFP 2002a).

The prevailing livestock production systems offered resilience and choices to shift between summer and winter quarters. This coping mechanism has shrunk to a large extent due to reduction in range feed resources because of drought. Kachhi plains and canal-irrigated areas of the Naseerabad Division were traditionally home to large nomadic/transhumant herds during winter. However, these areas have very little to offer during drought years.

Dropped leaves, fruits and weeds extracted out of orchards constituted an important source of supplementing the feed available for grazing. With 40% orchards in upland Baluchistan dried, cut and sold as fuel, this source of supplementary feed has virtually disappeared in several areas. The livestock feed resources have further reduced due to stoppage of fodder intercropping in orchards because of water scarcity. This has happened particularly in Panjgour and Turbat where date and pomegranate orchards have been traditionally intercropped with berseem and lucerne during winter (FAO/WFP 2000a; 2002b).

In a fairly large population of small ruminants, two breeding seasons (2001 and 2002) were completely lost because of reduced conception due to poor feed and health of the mothers. In many cases, pregnant animals aborted and a 10-15% lamb/kid mortality occurred due to shortage of milk with mothers. The stock buildup capacity has, thus, been drastically reduced and flock replacements are not becoming available to many graziers (FAO/WFP 2002a; 2002b).

Traditionally, livestock provides ready cash whenever needed to meet the household needs, but most farmers' ready cash has depleted. The situation has become particularly serious for those having livestock as the sole means of subsistence. Most of the small ruminant herds have been grazed by hired graziers, which was a source of employment. Reduced stocks have resulted in fewer jobs adding to unemployment.

The availability of meat, milk and milk products, as part of the family diet, has either totally disappeared or drastically reduced adding to malnutrition and poor health, particularly in children and nursing mothers. Due to malnutrition and poor health of animals, both quantitative and qualitative reduction has occurred in the production of wool and hair. Poor-quality products were sold at 50% of the normal price. The cottage industry has been adversely affected (FAO/WFP 2000a, b; 2002b).

Recently, due to reduced availability of stock, the small ruminants were sold at a higher price in Baluchistan and the mutton prices went up by almost 60%. In Sindh, drought-affected areas in the five districts have a total livestock population of 5.6 million heads. In normal years, about 20% flock owners from these districts shift to canal-irrigated areas taking along 15-20% small ruminants and 80% cattle. On-farm jobs, particularly related to rice and sugarcane harvest, are available in the irrigated areas to these migrant flock owners. Sugarcane tops and rice straw constitute a major source of feed for their livestock. If required, fodder is also purchased or traded against wage labor. Drop in acreage of major crops due to reduced availability of irrigation water in the canals has reduced the quantity of these feed supplements available for the migrating livestock and has also shrunk the job market. As the availability of crop residues and range biomass in the drought-affected areas has continued to deteriorate further, there has been a larger migration of livestock, increasing pressure on the feed resources available in the irrigated areas (FAO/WFP 2000a; 2002b).

Over 50% of the livestock population in drought-affected areas of Sindh has suffered from malnutrition with a concomitant increase in disease infestation due to reduced immunity. The mortality rate of small ruminants has increased by 10-15%. Drastic reduction has occurred in their breeding efficiency with only 45-55% ewes/goats breeding during the 2001 and 2002 seasons. Almost 20 to 25% of the lamb/kid crop succumbed due to low milk availability during the drought of the last 2 years.

Households

Changes in diet. The normal diet of the people of Baluchistan in the pre-drought period comprised wheat bread, tea, meat, milk, yogurt, vegetables and fruit. Seasonal vegetables and fruits were a part of the normal diet of the people living in the rural areas of Sindh and Baluchistan, while meat and milk products were more prominent in the diet of people dependent on livestock for their livelihood, especially in Baluchistan. Drought has restricted the access of affected people to food items. Their present diet comprises wheat flour and tea in Baluchistan and wheat flour, onion and chili in Sindh.

Earlier, the people had at least two regular meals a day. Most drought-affected people were forced to subsist on one meal. Wheat flour is the principal item of expenditure of the family income, followed by cooking oil. As cash resources depleted, it became hard to purchase oil and most meals were uncooked, as they comprised bread eaten with tea, chili or onion. There was evidence of food substitution in some areas of Sindh where people have taken rice in place of bread for their evening meal. Because of the lack of animals people have stopped making laandi, a form of dried meat, the staple winter diet of the Pashtun tribes of Baluchistan, and also lassi, the buttermilk, a favorite drink in both provinces. No house had food supplies beyond a day or two. In areas where fodder was scarce, people were forced to share their bread with their animals.

The government's free food distributions have, from the point of view of those affected, promised much but delivered little. Many of those affected, particularly in Sindh, who would otherwise have migrated to the canal commands, stayed at their villages in anticipation of receiving government wheat. Those who did receive this aid mostly got it only once, as a short-term relief. Without regular follow-up of distributions, this wheat appears to have made no significant improvement in the overall picture of food security.

Changes in living patterns. Water is a primary need of those affected by droughts; the search for its regular supply has caused widespread migration. This has converted a large population of settled villagers into migrants or refugees. A large number of traditional migrants or nomads have been forced to settle in and around places having regular supply of water. This double load of settlers has caused undue pressure on host villages, by depleting their water sources. The competition for local work added to the pressure on the job market, and the relations between the existing population and refugees often resulted in conflicts.

Since other sources of income have dried up, members of the affected families were forced to involve in the search for supplementing family income through occasional work. Women who traditionally stitched and embroidered clothes for family use are now trying to do so for commercial purposes. However, women are not receiving adequate compensation for this work because of the absence of markets for their products and reduced demand. Child labor has increased; older boys are now being sent to towns and larger villages in search of employment. Farmers are undertaking town jobs of the kind they have no training or aptitude for, and are being paid less than normal wages.

Since most of the family income is spent on the purchase of food, there is usually no cash surplus for buying other essentials (clothing, bedding, soap). This, together with the lack of water for cleaning purposes, has led to very unsanitary and unhygienic conditions prevailing in the houses and shelters of drought-affected families (FAO/WFP 2002a).

Health impacts. Use of brackish water in arid zones is an underlying cause for the poor state of human health. The method of water transportation and storage (ponds, tanks and plastic containers) exposes it to various forms of contamination. This is why the most common health complaints relate to diarrhea, vomiting and fever among children. This, together with a poor diet, has caused the widespread malnutrition reported among women and children by FAO/WFP (2002a, b). Diarrhea and enteric disorders were found in 30% of the children. Women were seen as affected by malnutrition as children. The impact of malnutrition was particularly severe on pregnant and nursing women, who have a greater demand for food energy. Because of illness and frailness, many of them complained of having no breast milk for feeding their babies. Since there was no adequate alternative to mothers' milk in the villages, or any proper weaning foods, the life of the infants appeared to be at considerable risk (FAO/WFP 2002a, b). Malnutrition also increased the vulnerability of those who were affected to such catastrophic diseases as tuberculosis and hepatitis.

Vulnerable groups. Women and children have been affected more by drought. While men have the option to go to work in towns where they have a wider choice in food and access to clean drinking water—which is reflected in their visibly better state of health—the women remain tied to the house. Their burden increases when the men are away because they have to take care of the entire household needs, even those that are normally taken care of by men, such as collecting firewood and fodder and the sale of animals in emergencies. Women are at the tail end of the family meal. They eat whatever is left after the men and children have eaten. Women also bear the burden of anguish when their children do not get enough to eat or when children's essential needs remain unmet.

Children's food needs are also more varied because of their growing age. Devoid as it is of most essential nutrients, their diet invariably leads to malnutrition and other diseases. Night blindness, scurvy and anemia are common among children and are caused by the lack of vitamins A, C and B12 in the body. Further, children do not discriminate between good and bad food when they are hungry. They often eat stale or contaminated food, which causes the high incidence of gastric and intestinal disorders (FAO/WFP 2002a, b).

Water Harvesting and Conservation

Traditional Methods and Their Extent

Water harvesting is a common practice in arid areas of both Sindh and Baluchistan provinces. Water harvesting captures rainfall and/or runoff and utilizes it for drinking or farming either directly or by storing it in small surface and subsurface reservoirs. The stored water can be used for supplemental irrigation and other consumptive uses. In nonirrigated areas, the majority of farmers are still practicing traditional water-harvesting systems, which date back even to 3000 BC. Traditional water-harvesting and -conservation practices common in the provinces of Baluchistan and Sindh are briefly described below.

Karezes

The karez or qanat is one of the oldest traditional irrigation systems of Baluchistan (as well as in neighboring Afghanistan), which was devised as a means of tapping groundwater supplies using gravity flow. It is a gently sloping tunnel that conveys water from below the water table to the ground surface. It consists of a series of dug-wells and tunnels that collect groundwater and discharge it to the command area. Each karez delivers water to the fields of shareholders, who have contributed money and labor for its construction. The 'modern' karezes are typically 1 to 5 km long, but have been as long as 50 km in the past. In areas having very low rainfall, and having little capacity for storage of surface water, the karez is the primary mechanism for water harvesting and delivery in Baluchistan. The residents of an area mark the site where the precipitation drained into an underground formation followed by the appearance of water a few kilometers downstream of the command area. The man who organizes villagers to begin and complete the arduous task of building a karez and maintaining it over time holds the office of Sarishtra, the manager of a karez. The Sarishtra holds the land immediately adjacent to the "daylight point" from which the water is discharged.

The residents first dug a well down to the groundwater table. This well is called the mother well (figure 2). In the expected direction of groundwater flow, more wells at a distance of 50-100 meters apart are dug to check the flowing water. Once a karez is established, it can be used for years. A census in 1998 revealed that there were 493 karezes in Baluchistan (IUCN 2000). An average karez can irrigate 10-20 hectares. Karezes, which yield up to 200 liters/sec normally, serve a maximum of 200 shareholders.

A karez is a perennial source of water both for domestic and irrigation purposes. In places without a freshwater supply, karez water is used for drinking, washing of clothes, cleaning of utensils, etc. A few decades ago, the agricultural economy was totally dependent upon the supply of karez water. The area irrigated by karezes in Baluchistan decreased from 14.2% in 1980 to 7.5% in 2000 (GOP 2000).

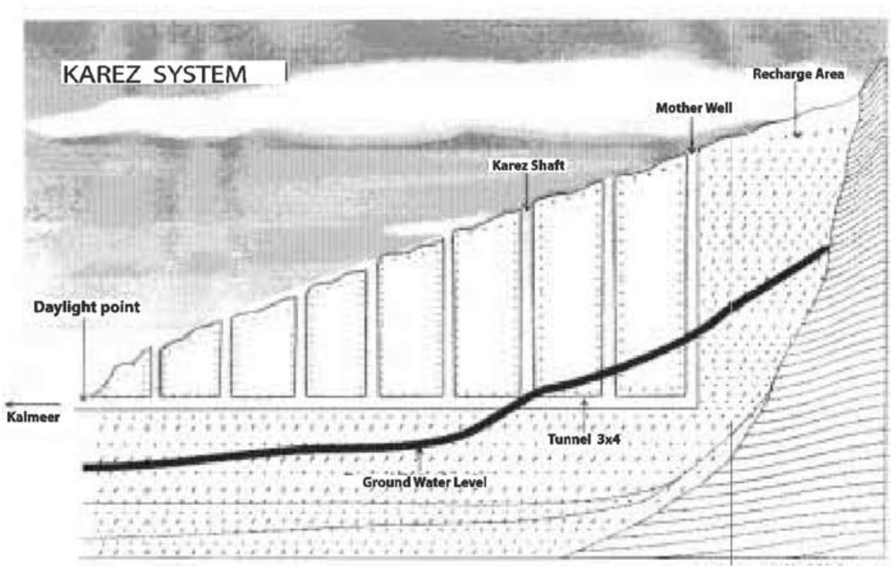

***Figure 2**: A schematic cross-section of a karez system.*

Sailaba or Rod-Kohi System

The sailaba or rod-kohi system is widely practiced in the Sindh and Baluchistan provinces. The sailaba cultivation is done by diversion and spreading of intermittent flows of hill torrents. As the water comes down the hill, it is checked by a series of earthen diversion bunds. To meet their local irrigation needs small communities have constructed diversion bunds on a number of smaller streams for irrigation. The water thus checked is allowed to seep slowly down into the soil. Water rights have been historically determined. Water can only go through the main, predetermined channel. The water is allowed to flow out of the side water channels only when there is excess water. Relatively large fields, each over 3 hectares, may be irrigated in this system and deep-rooted crops are usually recommended. The hill-torrent areas in Baluchistan are the Kachhi, Zhob-Loralai, Makran coastal area and the Kharan closed basin, and in Sindh they are the Karachi area, Khirther range and Sehwan and Pataro areas (Ahmad 2001; 2003a).

The potential for sailaba in Baluchistan is estimated as 1.1 million hectares. The historical data, however, indicate that sailaba cultivation has decreased from 0.33 million hectares in 1980 to 0.17 million hectares in 2000 (GOP 2000). The floodwater in the sailaba system is collected in two different ways: troughing the bandat systems and diversion of ephemeral streams.

Bandat systems. In the valley bottom, large bunds are made by farmers to serve as field demarcation boundaries and to trap runoff water. In this system, 0.5- to 3-m high bunds (earth embankments), depending on the topography of the land, are constructed on the main seasonal riverbeds to divert floodwater and lead it to the bunded fields (Khan 1994). The floodwater originating from the upper Loralai district flows through parts of Loralai, Kohlu and Sibi before entering the Sindh province. The bunds have been traditionally built by animal labor (camel and bullocks) but now it is common to see increasing use of bulldozers and tractors. The bunds are simply banks of earth. Farmers raise their crops on areas where runoff is collected.

Diversion of ephemeral streams. Another common practice in upland Baluchistan is to terrace stony land alongside ephemeral streams at the top of the valleys, near the mountains, and divert the stream flow into the fields by dams extending into the streambeds. Stream flow generally occurs following the intense storms of the monsoonal period, bringing sediments from the surrounding hills, which provide nutrients for crop production (Rees et al. 1987).

Khushkhaba System

The Khushkhaba system comprises in-situ conservation of incidental rainwater and catching runoff from large uncultivated blocks and diverting it to cultivated fields. Fields receive water directly from precipitation or from localized runoff. The khushkhaba is merely a chance cropping with a successful crop being raised on average once in 5 years. The main difference between the khushkaba lands and the sailaba lands is that the catchment area of the former is small and is often not bigger than the field enclosed by the embankment or bund. Embankments are made facing the hills, so that the natural gradient within the bunded area helps collect the runoff above the embankments (Khan 1994). The area inside the bund is deliberately left uneven with the areas closer to the bund being the lowest. This is done so that, in the case of high rainfall, the runoff from adjacent areas upslope collects near the embankments and provides enough water at least to grow crops in the lower half of the fields (0.5-1% slope), and to encourage rainfall to run off into the tilled bunded field below to increase both its soil-moisture content and, consequently, the yield of the dryland crop. It is mainly practiced in Quetta-Sarawan and Zhob-Loralai areas of the Baluchistan province. The area under khushkaba cultivation in Baluchistan was estimated as 0.32 million hectares in 1980 and 0.34 million hectares in 2000 (GOP 1980, 1990, 2000).

Tarai

The most common type of water conservation in the arid regions of Sindh is a dugout commonly called "tarai." Tarais collect rainwater for water supply and are filled from the water drained from a level watershed and collecting area. They could be dug cheaply in low-lying areas with clay soil where there is some runoff. The depth of water in a tarai is normally 3-4 m. The water from tarais, which is less than 3-m deep, is fast lost through evaporation. The evaporation rate is relative to the amount of runoff received and its frequency during a year. The evaporation rate in drought-prone areas is significant, as there are prolonged dry spells with no rainfall or runoff received during the dry year. Therefore, the tarai depth is normally twice the annual evaporation in the area. They are dug so deep as to hold water for long periods. A tarai has sloping sides so that livestock can have access to water. Desilting is needed after 3-4 years.

Small Dams

Small dams on channels and streams, however, collect and store more water than tarais. Several such dams have been constructed in hilly and mountainous areas at some places on the streams to store rainwater.

These are typical in the Kohistan area of the Sindh province. The reservoir of water in small dams can serve both animals and human beings. In the Kohistan region, particularly where many rainwater streams (nain) flow heavily during and after rainfall for a considerable period, such reservoirs retain water for some time after the end of the rainy season. The soil retains moisture for longer period to support dryland agriculture.

Wells

In most of the rangelands, the dependable and common source of water is wells, where groundwater is of usable quality. Water from the well is raised manually or by animal power. The wells are usually dug along the riverbeds and channels to harvest the shallow seepage water.

A comparison of the area irrigated by different sources during the selected decades in the Baluchistan and Sindh provinces is presented in table 4.

Table 4*: Area irrigated by different sources (GOP 1980, 1990, 2000).*

Area (ha)	Baluchistan			Sindh		
	1980	1990	2000	1980	1990	2000
Total cultivated area	995,710	1,163,387	1,271,872	3,167,054	2,874,033	3,255,334
By canal only	177,594	206,690	281,859	2,285,259	2,132,546	2,658,510
By canal and tube well	—	—	15,689	164,112	134,226	154,912
By canal and others	—	—	—	8,207	—	—
By tube well only	40,779	105,629	202,281	51,813	44,080	40,181
By well only	8,488	—	—	3,312	—	—
By karez only	49,218	54,096	52,750	—	—	—
Tank/bandat/rod-kohi/spring	39,955	—	—	8,927	—	—
TanM)andat	—	38,415	12,399	—	7,772	7,457
Spring/rod-kohi	—	127,430	89,437	—	30,223	44,983
Unspecified	30,213	58,244	47,624	6,753	2,074	529
Not irrigated	—	—	55,274	97,779	48,807	64,015
Sailaba	330,370	192,255	172,482	35,200	12,398	3,042
Barani	319,106	380,644	342,074	505,701	461,905	281,706

Effectiveness of Traditional Water Conservation during Drought

Karezes

The efficiency of the traditional karez systems has been negatively affected during the last 20 years for two reasons. First, due to recurring droughts, and second due to the installation of a large number of tube wells and dug-wells (more than 25,000 functional tube wells exist throughout Baluchistan at present). The rate of depletion of groundwater in Baluchistan has been accelerated from approximately 0.2 meters per year (m/yr.) prior to 1989 to the present rate of 1 to 1.5 m/yr. (Khan 2002). The installation of a large number of tube wells has contributed significantly to lowering the groundwater table, which has dropped from 15 to 80 m in the last 30 years. The latest drought has devastated entire ecosystems as water supplies for domestic use, agriculture, water and vegetation recede or vanish altogether. A key advantage of the karez is that it delivers water year-round, even in years when rainfall is below average. According to Appell et al. (2003), during the recent drought in Baluchistan, the karez continued to deliver enough water to meet people's needs for about 2 years. However, due to the continuous drought condition, natural flows in karezes and springs are also drying up. Community-owned and -maintained karezes were replaced by private wells owned by a few individuals.

During the last decade, the government departments, National Rural Support Programme (NRSP) and NGOs working in the area have restored nearly 200 karezes. Till July 2002, NRSP and its community organizations had rehabilitated 112 karezes in Turbat, benefiting over 13,000 households (Appell et al. 2003). In some areas, including those close to the Dasht river, the karez is a vital link to water-storage facilities. The government has recently built a number of water-storage bunds, which are also linked to the karez system.

Sailaba and Khushkhaba Systems

Crops grown under these irrigation systems give poor yield and return and thus the investments are very risky. However, these farming systems in conjunction with livestock do provide an off-farm income, which is the major source for many of the poor farming communities. These types of water-harvesting systems are dependent on the monsoon, which is unreliable in upland Baluchistan. Due to below-normal rainfall during the past 4 years, many parts could not receive enough rains to recharge the water sources. The abrupt decline in rainfall (less than 50% of normal) in most of the uplands has caused complete drying of water sources for domestic needs. The long period of moisture stress during the drought coupled with shallow rooting results in very low yields. Both sailaba and khushkhaba are managed in traditional ways. These systems serve only to meet the barest needs of the farmers. In the most severely drought-affected areas of Baluchistan, cropping of khushkhaba and sailaba types has totally disappeared. In areas severely or moderately affected by drought, crop areas have reduced by 60 to 80% with productivity going down by almost 50% due to moisture stress. Stream flows available for sailaba cultivation have either totally dried up or drastically reduced because of failure of rainfall (Chaudhri et al. 2002). The area under wheat, barley and sorghum has registered drastic reductions of 84%, 96% and 95%, respectively.

During the drought and dry spells of the last few years, the floodwater was received in reduced quantity and, consequently, the command area was severely affected. The farmers either harvested the wilted crop or could not cultivate due to water scarcity.

Tarais, Small Dams and Wells

In Sindh, very limited efforts have been made to accumulate the rainwater that may be utilized for cultivation of land. Several projects like mole dam, Kacho reservoir, development of lakes, depressions and reservoirs are lying unattended and ignored for many years. These water bodies can substantially harvest the rainwater for using it for valued crops. During the recent drought, the districts of Tharparkar, Kohistan and Dadu were severely affected and Tarais either dry up completely or become heavily polluted. The other water sources like ponds have dried up due to extreme drought and water in the wells has also fallen. With the drying up of sources of water, the herders had to move 10-12 km to water their animals and, during extreme scarcity, they out-migrated to irrigated areas (Isani 2000). Due to lack of moisture, crops such as millet, guar and grasses have dried up completely and overgrazing has caused poor vegetative cover, resulting in desertification.

New Water-Harvesting and Conservation Methods

Runoff-Runon Systems for Khushkaba Areas

The dryland-farming system of upland Baluchistan faces many constraints mainly due to low and erratic rainfall, which varies from 150 to 300 mm annually. The dryland farmers classify 3 to 5 years out of 10 as a poor crop year with low grain and fodder yields. The farmers have, therefore, developed several water-harvesting practices that minimize production risk. Based on the observations of the valley-bottom soils, Rees et al. (1987) suggested more modest and practical interventions. Since crop growth in the upper portions of most fields is usually patchy and poor, the possibility of treating this unproductive land lies in reducing infiltration of rainwater and increased runon in the cropping area near the bund. The upper portion was treated either by plowing to remove vegetation and loosening the soil or by heavy planking to pulverize and level the soil or by wetting to induce crust formation. This wetting can be artificial, using an outside source of water or the first rain of the season will cause crust formation after the pulverization treatment of the soil. Other treatments such as concreting or mixing salt with soil to engender a strongly impermeable crust are possible but these are much more expensive than the treatments explained above. This technique has produced a satisfactory crust on both a sandy loam soil and a sandy clay loam soil. According to Rees et al. (1987), these interventions have resulted in additional soil-moisture storage in the cropping area near the bunds.

Water Ponds and Storage Tanks

The available water sources in mountains and deserts of Baluchistan have often a small discharge and the direct application of this low flow results in higher conveyance and application losses. A standard size water pond is an integral component of a farm's infrastructure throughout Baluchistan. Before the rains, people normally construct small ponds, which are either mud-plastered or cemented, to store/conserve rainwater for domestic use and, in some cases, for animals. The size of these ponds varies from place to place. The stored water is available for a period of 4 to 6 months, depending on the size of ponds, prevailing weather conditions and its use (FAO/WFP 2002a). Water ponds constructed in these areas conserve water by increasing the volumetric flow through its intermittent and timely releases. The Pakistan Council of Research in Water Resources (PCRWR) has developed 6 ponds in the Cholistan desert to collect rainwater runoff from 90 hectares of land. These ponds have been designed to catch maximum rainwater in the shortest possible time to avoid water losses. The depth of ponds varies from 4 to 6 m with a storage capacity from 2,000 to 5,000 m3 (Bhutta et al. 2002). Farmers plant timber and forage trees all around the pond to meet their domestic needs. The advantage of ponds is that farmers keep their ponds filled round the clock, using them as and when the need arises, and selling this water to neighbors. An additional advantage is that earthen ponds also recharge the groundwater.

PARC has developed earthen ponds and storage reservoirs in both the target areas, where the variable depth concept is used so that during the dry spell the water in a reservoir can be restricted to a smaller area with a larger depth to ensure water availability for longer durations. The sand filters coupled with hand pumps around these ponds provided a low-cost technology for rural communities' water supply. In addition, in the areas of Barkhan and Musa Khel districts, facilities for washing clothes and water were provided to maintain the quality of the stored water. Rural communities were motivated to restrict the entry of livestock to the ponded area to avoid associated water pollution (Ahmad 2001).

In Sindh, a number of storage tanks and new tarais (plus a number of rehabilitated ones) were built or are under construction. The capacity of tanks depends on the intensity of rainfall but, in general, the rainwater-harvesting practices are feasible in areas receiving more than 150 mm rainfall annually.

Artificial Recharge to Groundwater

Due to the continuous overdraft, Baluchistan's groundwater aquifers are dropping at 3.5 m annually. In Sindh, less rainfall and reduced flow of water in rivers and canals have also affected the groundwater recharge, resulting in the progressive lowering of the water table. Reduced stream flow has particularly affected the dug-wells along their course, creating a serious drinking water problem. The most critical issue, therefore, in both provinces is how to stabilize and maintain the groundwater table. One possible solution is artificial recharge of groundwater. The artificial recharge techniques include a) plantation of appropriate plant species, b) "inverted" well, c) recharge dam, d) loose-stone check dam, e) deep dug-wells, f) ponds and recharge basins, g) depression, h) benching, and i) spreading of water.

Plantation. The plantation reduces the rate of runoff by trapping and delaying the water with associated reduction in the level of silt carried in the floodwater. This technique results in significant impact on water conservation and improvement in Baluchistan, having sufficient soil cover. Studies reported that an 80 mm storm of rainfall on vegetative catchments could produce a lower peak flow than that from a 20 mm storm in catchments without plantation. It is also reported that the vegetative measures can add around 33% more to the groundwater recharge (Majeed 2000).

Recharge dams (delay action dams). This technique consists of constructing dams across streams to store floodwater for recharging of groundwater. The dams delay the passage of floodwater by retaining it behind impoundment structures. Recharge then takes place by infiltration behind the structures through the reservoir bed. A number of such dams have been built in Baluchistan and Sindh over the last two decades. These are popularly known as delay-action dams. Unfortunately, many of these do not have any means of releasing water downstream of the dam. Typically, they have high initial recharge rates due to high porosity of the bed but these rates then fall exponentially with each rainstorm due to high silt load brought in by the floodwater. A limited case study on the effectiveness of such dams was conducted on the Pechi delay-action dam near Ziarat using water balance, isotopic and chemical techniques. The purpose of the dam was to collect rainwater in the flood season and to supplement the nearby karezes by recharging groundwater. The study failed to establish any hydraulic interconnection between the dam reservoir and downstream karezes. The main reason was sedimentation of finer materials in the reservoir bed.

Recently, the PCRWR constructed a leaky dam near Quetta with an aim to overcome the problems faced in delay-action dams. The main feature of this dam is that, contrary to the existing practice in Baluchistan, the main body of the dam is leaking. The structure of the dam is gabion with stones held together with wire mesh. The dam is built so that it allows the slow release of water through its body for recharging groundwater. The dam body also has the provision for release of water through a number of gate valves, which could be used once the dam structure gets clogged with sediments. A monitoring system has also been placed to check the effectiveness of the dam for recharging groundwater.

The results of some studies regarding the effectiveness of delay-action dams indicated that these structures enjoy considerable popular support in Baluchistan. The Executive Committee of the National Economic Council (ECNEC) has recently approved the construction of 54 delay-action dams, estimated at almost US$8 million. These will be built in Quetta, Pishin, Mastung, Qila Abdulla and Mangochar. The Japan International Cooperation Agency (JICA) has also offered a grant of around US$14 million for the construction of five delay-action dams. The Asian Development Bank (ADB) and the World Bank (WB) have also agreed to finance desiltation of delay-action dams and construction of new dams under the National Drainage Program of Pakistan. All this is expected to contribute positively to groundwater recharge. The efficacy of delay-action dams can be enhanced by providing exit pipes for draining the silt-free water downstream for infiltration into the streambed.

In the Sindh province, the Society for the Conservation and Protection of Environment (SCOPE), a Pakistani NGO working on the implementation of United Nation Convention to Combat Desertification (UNCCD) constructed a small retention dam to save land and water resources of the Gadap area, an agricultural greenbelt in the Malir district of Karachi in the Sindh province (SCOPE 2002). Malir, which was once known for its abundance of arable land and water resources, became desertified due to excessive sand and gravel excavation from the beds of hill torrents, groundwater exploitation and prolonged recurring droughts. The groundwater level dropped from some 20 m in 1960 to 90-200 m in 1999. Owing to the scarcity of water, out of 29,210 hectares, only 2,600 hectares of land are cultivated. With the construction of a 3.5-m high check dam in the Khar valley of the Malir district, the rainwater can be stored for domestic purposes and to recharge the groundwater aquifer. The Raingun Sprinkling Irrigation System was installed to economize the use of irrigation water at two different farms in the Gadap Union Council. Since the construction of the weir, runoff has been successfully stored in the lake. This lake is able to store water for most of the year and the groundwater level in the adjacent area has risen sharply. Many dried wells and water holes become functional. After every monsoon, rainwater percolation increases and aquifers are being replenished. The Sindh Arid Zone Development Authority (SAZDA) carried out studies for the construction of small dams in Kohistan and Thar regions (Rahamoo 2004).

In the Zhob district of Baluchistan, Human Development Foundation (HDF), in partnership with the local communities, constructed a delay-action dam for recharging groundwater. The dam has a capacity to store about 110,000 m3 of water and the catchment area is about 12 km2. Before the dam was built, there was little vegetation around. In 2002-2003, a few rains filled the dam to a depth of over 8 m. This has raised the water level in the karezes and wells in the vicinity of the dam, on average, to about 3 m. HDF also helped the community to install hand pumps in the villages to provide water for domestic use. Traveling long distances to collect water from earthen ponds, which is not safe for domestic use, has stopped.

Recharge wells. This technique basically consists of drilling a borehole to provide a direct path for water to infiltrate and to recharge the groundwater. The water may flow under gravity or may be injected through reverse pumping. It is reported that good recharge rates can be achieved through injection wells to an average ranging from 1,235 to 5,725 m3/day with a minimum of 200 m^3/day. Dug-wells can also be used as a recharging device.

Unfortunately, very often a precipitation of less than 25 mm occurs, which seldom results in any runoff. Rainfall of more than 25 mm often occurs after a long dry spell and is not effective.

Occasional precipitation causing a runoff carries a large amount of sediment, which is harmful to the success of artificial recharge practices in Baluchistan.

Hand Pumps

In areas where the groundwater table is not very deep, the hand pump is the best solution for domestic water supplies. In Aranji sub-tehsil of the Khuzdar district, Baluchistan, the water table in several places during the recent drought was about 12 m. About 30-35 hand pumps were installed under the UN World Food Programme. One hand pump is sufficient for some 50 persons. Furthermore, the Public Health Engineering and Irrigation & Power Department of Baluchistan has installed around 28 tube wells and 50 hand pumps to meet the water shortage for irrigation and drinking purposes in various districts (Khan 2002a, b). The local communities welcomed this technological intervention.

In the Sindh province, there are 37,391 tube wells installed in the public and private sector. In view of the overall situation of drought in the province, over the past 3-4 years, the number of tube wells has increased by around 60% from 1997-1998 to 2000-2001. A new scenario has emerged whereby the water zone is being exhausted through excessive pumping of groundwater through tube wells. The Rotary Club of Karachi Sunset Millennium, together with Pakistan Insaf Welfare Trust (PIWT) has installed 180 hand pumps in the drought-affected areas of urban Sindh. PIWT has evolved a system through which the community having 300 or more persons is entitled to have a water pump. The pumps were installed at a public place or at a community center like a mosque, so that everyone has access to the water.

Improved Tillage and Furrow-Ridge Planting

Although this is not strictly a drought-proofing measure, improved tillage may lead to increased yields, which is important for creating food reserves. The effect of tillage on crop growth and yield is not only to increase infiltration of rainwater but also to break the hardpan, which allows better root growth or increased nitrogen minerlization of the inverted soil.

Farmers in Baluchistan are using a dual-purpose plowing and planting implement, the 'desi-plow.' This produces ridges 8 to 15 cm high, depending on the soil type and pushes the loose soil to either side to form a ridge-furrow system. This enables farmers to place seed in moist soil by planting 4 to 6 cm below the bottom of the furrow. Rees et al. (1987) observed that following 47 mm of rainfall, the soil water content of the basin increased by 24 mm, whereas that of the furrow-ridged system increased by 57 mm. Both in Sindh and Baluchistan, most of the crops including wheat can be sown on ridges, which can save about 30% of water.

High-Efficiency Irrigation Technology

In most of Baluchistan, irrigation methods commonly followed by farmers include the controlled flood-irrigation technique on either wide-border strips or basins. In some areas, where soil is sandy, gravity irrigation results in significant wastage of water due to seepage. Almost all fruits, vegetables and winter fodder crops are overirrigated. As much as double the amount of water required is applied. The application efficiency in fields is 25-40% (IUCN 2000).

During the early 1990s, PARC, with the collaboration of the local industry, started producing high-pressure pumps for agricultural purposes, local manufacturing of sprinkler and drip irrigation systems (polyethylene-based). The local production of sprinkler and drip-irrigation systems helped the local people to start installing these systems. However, large-scale adoption of these systems in Baluchistan is limited due to low value of water and heavily subsidized electricity tariff. The subsidy on electricity consumed by the farmer is around 90%, where the farmer is supposed to pay only 10%, as a fixed rate of Rs4,000 (around US$70) per month. The other root cause for the adoption of these systems is the nonexistence of local irrigation companies in the provinces.

PARC collaborates with the local companies to initiate local production of PVC-based drip irrigation systems and to establish local dealership and irrigation companies for the installation of these systems. The installation of demonstrations throughout Baluchistan and in other parts of Pakistan is now ongoing. The Government of Baluchistan with the assistance of the Khushhali Bank is considering the formulation of a Water Conservation Fund, where assistance will be provided to the farmers through the Khushhali Bank, and systems will be installed by the private sector on a turnkey basis. The installed cost (capital plus installation cost) for the drip irrigation system by Engro-Asai supported Company of Civic Abyari is less than Rs50,000 (US$880) per hectare. PARC in collaboration with the local pump industry has also indigenized Raingun sprinkler irrigation systems (Hussain and Yasin 2003).

Watercourse Improvement

Considerable wastage of water occurs in watercourses. The main causes of operational losses are seepage, overflow, vegetation and rodent holes. Currently, the supply of canal water to the Pat Feeder and Khirther canals in Baluchistan is supplemented by more than 25,000 public and private tube wells in Baluchistan. Nearly 40% is lost in the delivery system due to improperly designed and maintained watercourses. Only 60% of water reaches the fields where field unevenness further accentuates the losses by 20-25% (Gill et al. 2002).

In the Sindh province, watercourse losses were in the range of 44%. After lining with PVC geo-membranes, water losses were reduced to less than 3% (Kazmi 2001). The Government of Sindh is also negotiating a watercourse-lining project with the WB. The project will be implemented in 28 villages of 4 districts of the Sindh province covering a total length of 50 km with 1.8 km per village (Memon 2002). Overall, in Pakistan about 33% of total watercourses have been improved.

Furrow-Bed Irrigation

The basin irrigation method is commonly used in the Sindh and Baluchistan provinces, with the highest water consumption and the lowest water use efficiency. Furrow-bed irrigation is considered the most efficient method of water application. Raising row-crops like cotton on beds with row-to-row spacing of 75 cm is gaining popularity amongst the farmers, mainly because it saves water; the cost of crop production is also substantially reduced. IWMI has conducted furrow-bed irrigation trials in cotton-wheat regions of Punjab and Sindh and results have been very encouraging. Planting of cotton on beds and furrow irrigation have resulted in a 30-35% increase in yield with around a 40-45% saving in water (IWMI 1999a). The technique is also being evaluated for rice production and has the potential to grow rice with less water (Gill et al. 2002).

Zero-Till Technology

Zero-till drill and production technology was developed by PARC during the late 1980s. PARC worked with the local manufacturing industry to initiate the local manufacturing of zero-till drills. Zero-till technology refers to planting crops without seedbed preparation. This technology has been introduced in the Sindh province. It has been beneficially used for planting wheat without any seedbed preparation after the harvest of rice. It allows utilization and conservation of the antecedent soil moisture, saves time due to early planting and increases wheat yield (IWMI 1999b; OFWM 1998). Around 30-40% of water can be saved with zero tillage along with precision land leveling. The area under zero tillage in Pakistan has increased exponentially over the last 4 years with 20 hectares in 1996-97 to 78,500 hectares in 2001-2002 (Gill et al. 2002).

Laser-Leveling Technology

Precision land leveling (PLL) improves irrigation application efficiency and increases the uniformity of application with less chances of overirrigation or under-irrigation. It is becoming increasingly popular among the farmers because of its benefits in terms of higher water use efficiency and crop yield. At present, the Directorate of Water Management is providing laser levelers to the farming community on a monthly rent (Memon 2002). The data collected in Punjab revealed that 80% of farmers benefiting from this technology have smallholdings (Gill et al. 2002). The main advantages of PLL are reduction in application losses of up to 25%, reduction in labor requirement by 35% and increase in crop yield by 20% (Sattar et al. 2001).

Adjusting Cropping Pattern with Water Availability

High-delta crops like sugarcane and rice not only consume a larger portion of available water but also contribute to waterlogging. Wheat, cotton, rice and sugarcane are the major crops of Sindh, which constitute 68% of the total cropped area, while the horticultural crops that Sindh produces are banana (73%) mango (34) and chili (88%). The combined effect of the recent drought and reduced irrigation water supply reduced the cropped area and crop production of major crops in Sindh in 2001-2002. In Baluchistan, due to the drying up of a large number of karezes and natural springs and reduced discharge from tube wells, the cropped area was reduced and productions were negatively affected in the same period. The reduction in the production of major crops in Sindh (compared to 1998-1999) was in the range of - 4 to -40% and in Baluchistan of-8 to -20% (GOP 2003).

The Government of Sindh decided that low-deltaic crops such as sugar beet, cotton and oilseeds should replace the high-deltaic crops like sugarcane and rice in accordance with the soil and climatic conditions. Following this policy, the Ministry of Food, Agriculture and Livestock initiated a campaign in the Sindh province to replace sugarcane area by sugarbeet, which resulted in increased areas under sugar beet in the lower Sindh province during the year 2001-2002. Sugarbeet grew well and growers welcomed it as a promising rabi crop.

Rice is the other high-deltaic crop to be replaced with cotton. Cotton not only gives better income to the farmers but also the gross revenue per unit of irrigation water is much higher for cotton than for rice (Memon 2002).

Existing and Required Institutional Mechanisms for Implementation

Departments of Agriculture (provincial and district) and water user associations (WUAs) are responsible for implementation of Watercourse Improvement and Construction of Water Storage Tanks. Under the Local Government Ordinance of 2001, the Department of Agriculture was decentralized, and among others, water management functions of the OFWM Directorate were also devolved to the District Governments.

The Department of Agriculture is the lead implementing agency and the provincial Directorate of OFWM has the overall responsibility for social mobilization to establish WUAs to implement watercourse improvement and construction of water-storage tanks. The Director of OFWM acts as the Project Director for the national and provincial programs and is responsible for implementation of projects through the District and Field Teams.

Laser leveling has been introduced in both the provinces under the OFWM projects. For large-scale introduction of this intervention, the federal and provincial governments are in the process of shifting this responsibility to the private sector and the farmers' institutions including the WUAs. The OFWM training institutions would be responsible for the training of the tractor operators and the engineering staff. The import duty and taxes on laser-leveling equipment have been removed under the recent package announced by the President of Pakistan for the farmers. As the laser-leveling units are now being produced locally, it is expected that repair and maintenance facilities would be available to the users shortly. Similarly, zero-till and the OFWM and Agricultural Extension staff in both the provinces are introducing furrow-bed systems.

In the Baluchistan province, the Irrigation and Power Department (IPD) is the main public-sector agency responsible for the planning and operation of irrigation schemes. The Public Health Engineering department, in collaboration with the local bodies and the Rural Development Department is responsible for providing drinking water to the rural communities. The Baluchistan Water and Sanitation Authority is responsible for the provision of water supply to the Quetta city. The IPD is responsible for developing major groundwater-development projects and installation of tube wells for the public-sector agencies and for private individuals. The PCRWR is involved in research related to the leaky delay-action dams in Baluchistan. The hand pumps are primarily installed by the local NGOs with the help of the Public Health Engineering and IPD.

In general, in the Sindh province, there is currently no established mechanism to promote and introduce the new technologies and to document their efficiency in mitigating drought impacts. Thus there is a need to have effective institutional mechanisms for the transfer of technology to the water users. Appropriate institutional arrangements are also needed for effective coordination between the line departments and the research and development (R&D) institutions in the province. Such arrangements are crucial to providing technical backstop and developing support to the rural and urban communities of the drought-prone districts. This could be accomplished by the establishment of an apex organization addressing the issues of drought and water management in the arid zones of the Sindh province.

A drought management plan is essential for the drought-prone districts of the Sindh province covering the Kohistan, Khirther range and the arid zones. The plan should include a clear coping mechanism to mitigate the impacts of droughts. Both Baluchistan and Sindh have limited water resources. But both still do not make efficient use of the available water resources. The existing irrigation-scheduling practices are still largely based on the conventional approaches of flood irrigation and have a tendency to overirrigate. To address this issue, an effective extension service is needed for the transfer of management practices and water-use-production technology to the farmers.

Farmers should be motivated and trained in the use of emerging efficient water-use methods such as sprinkler and drip irrigation, laser leveling, raised-bed planting, watercourse lining and water storage tanks, which have proven successful in different arid environments of Pakistan.

Due to the excessive exploitation of groundwater coupled with the successive and recurring droughts, groundwater tables in different parts of Sindh and Baluchistan have considerably declined. Traditional water-harvesting and irrigation systems often fail. This overexploitation of the resource has caused devastating impacts on drinking-water supplies for the urban and rural populations. To arrest this trend, the government needs to develop appropriate policies to effectively manage and monitor groundwater development and use. Steps should be taken for the revision and enforcement of water laws. Communities should be directly involved in the campaign of recharging the groundwater aquifers and in the conjunctive use and management of surface water and groundwater resources.

Prospects for New Technologies

Some of the interventions described have proved to be very effective and widely accepted by the farmers, planners and policymakers at the national level. The government is well aware of the huge water losses in canals and the need for On-Farm Water Management (OFWM) programs and is already developing a program for improvement and lining of 86,000 watercourses of the country to save water in the long-term (GOP 2004). Farmers have to share 55% of the cost of improving watercourses.

Under the OFWM-project funded by the WB, about 200 water-storage tanks, each with a capacity of storing 180 m3 and serving from 5 to 10 farms, would be constructed during the next 4 years on a cost-sharing basis. Using the Government Federal Grant, the Government of Sindh has undertaken development schemes (duration of 12 to 36 months), which include installation of tube wells, construction of delay-action dams, small dams, recharge dams, drinking-water supply through pipelines, introduction of drip irrigation systems in Thar and Kohistan regions and community-based cactus plantations in arid zone of Sindh (GOS 2000).

The Government of Baluchistan decided to allocate a similar-sized Federal Government grant of around US$16 million to projects identified as medium- to long-term drought-mitigation strategies. These include the construction of 11 dams, 250 windmills, development of 28 tube wells, 50 low-cost water supply schemes and uplift of 100 karezes (FAO/WFP 2000a, b). In Baluchistan, rehabilitating the karez is a significant means of restoring water supply to communities. National NGOs, such as NRSP with funding from UNDP and the Federal Government have rehabilitated 112 karezes in Turbat. The introduction of high-efficiency irrigation systems has potential to improve water distribution and efficiency within the karez system.

In Pakistan overall, currently about 0.7 million hectares of land are being irrigated the through the rod-kohli system, where water is diverted from the hill torrents. There is a potential to irrigate 2 million hectares of agricultural land and this would need an investment of about US$85 million (GOP 2004).

Under the 10-year Perspective Development Plan (2001-2011), pilot projects for the sprinkler/ drip systems over 4,000 hectares will be undertaken in the country (GOP 2001). In Baluchistan, where indiscriminate expansion of authorized and unauthorized tube wells and the overirrigation of orchards and vegetables have led to mining of groundwater aquifers, such systems are most appropriate and have a great potential. The drip-irrigation research concluded that it saves groundwater and significantly increases the yields of orchards.

Under the 10-year Perspective Development Plan (2001-2011) of the water sector, precision land leveling of about 150,000 hectares will be undertaken in the country (GOP 2001; GOP 2004). Due to lack of suitable arrangements for providing equitable access to farmers, so far only a limited number of demonstrations were possible, and these have been generally targeted for relatively large farms. The Government of Sindh is planning to consider a PLL program in each district by making the equipment available to the farming community on a cost-sharing basis. The prospects for the adoption of this technology are very high in future.

The land, water and climate play an important role in the adaptation of a cropping pattern but traditions affect the decision making. Many crops are still grown in places where other crops are more appropriate. Change of cropping pattern can have a significant effect on water savings. In the Sindh province, the production of sugar is much higher than the requirements of the province. Ahmad (2003b) proposed (in combination with improvement of watercourses and lining of canals) a 10-year strategy to reduce the rice and sugarcane cultivation by 20% and increase yield by 20% to meet the shortfall due to reduction in area. It is essential for Pakistan to introduce new crop zoning and cropping patterns to efficiently utilize the scarce water.

Current Institutions and Policies for Drought Mitigation

Drought Monitoring

Monitoring of drought-related hydrometeorological and other variables in Pakistan is carried out by several agencies, including the Pakistan Meteorological Department, Water and Power Development Authority, Provincial Irrigation and Drainage Authorities and District Governments.

Pakistan Meteorological Department (PMD)

PMD is a federal agency under the Ministry of Defense, with a mandate to monitor and analyze meteorological parameters including drought events. It maintains a network of about 200 meteorological stations across the country. A Drought and Environmental Monitoring Centre (DEMC) has been established within the organizational setup of the PMD. This center has planned to install 350 additional meteorological stations, particularly to strengthen the existing drought-monitoring system in the country. The DEMC has also established the Regional Meteorological Centres in each of the four provinces to provide support for monitoring of drought at the provincial level. The Regional Meteorological Centers collect the real-time data of meteorological parameters and communicate these to the PMD headquarters for analysis (PMD 1999, 2000, 2003). Regional Meteorological Centres are located in Quetta (Baluchistan), Karachi (Sindh), Lahore (Punjab) and Peshawar (NWFP).

At PMD headquarters, data and information received from the Regional Meteorological Centres and shared with WMO are processed and synthesized using established methodologies and criteria related to drought indices to generate information related to drought hazards. If the numerical values computed using the drought indices indicate that a certain area has been engulfed in drought conditions, then PMD asks the respective meteorological station(s) to supplement the climatic findings with the physical surveys and ground-truth analysis in the drought-affected areas. If the ground-truth surveys also support the empirical findings, then PMD communicates the drought-alert signals the Home Secretary of the respective provinces and the Emergency Relief Cell within the Cabinet Division of the Government of Pakistan to take necessary measures in the affected areas.

PMD explores drought characteristics like intensity, magnitude and extent (spatial and temporal). For the assessment and characterization of drought events and drought-affected areas, PMD has been using Percent Normal Method, Aridity Index and Standardized Precipitation Index as drought indicators (PMD 1999, 2000, 2003).

Percent Normal is the simplest drought indicator and can be calculated by dividing the actual precipitation of any station with normal precipitation (typically based on 30-years' mean). If the rainfall is less than 40% of seasonal normal rainfall at any station for two consecutive seasons (winter and summer under Pakistani conditions), the drought conditions are set on for that particular station. PMD has identified drought-prone areas of the country by analyzing the historical precipitation data (1931-1988) of important locations. Time-series charts of the seasonal rainfall amounts thus developed have revealed that the higher the seasonal normal values, the lesser the chances of drought incidence and vice versa. As a result, Northern Areas, NWFP and parts of the northern Punjab have seldom experienced droughts, where seasonal normal is higher due to the presence of western disturbances. Contrary to these, the areas lying in the south and southwestern side of the country (Sindh and Baluchistan and Southern Punjab) have lower seasonal normal and, consequently, have more drought-prone features.

Aridity Index (AI) was used by the PMD as a criterion to evaluates drought-severity conditions (light, moderate or severe). The Aridity Index is defined as a ratio of 50% probability of rainfall to the actual crop evapotranspiration. The computation of Aridity Index requires data on precipitation and reference crop evapotranspiration. Meteorological data of temperature, humidity, and wind speed and sunshine hours are needed to compute the reference evapotranspiration.

Standardized Precipitation Index (SPI) quantifies the precipitation deficit for multiple time scales. These time scales reflect the impact of drought on the availability of different water resources. The SPI calculation for any location is based on the long-term precipitation records for a desired period. This long-term precipitation record is fitted to a probability distribution, which is transformed into the normal distribution so that the mean SPI for the location and desired period is zero. Positive SPI values indicate greater-than median precipitation, while negative values indicate lesser-than median precipitation. Because the SPI is normalized, wetter and drier climates can be represented in the same way, and wet periods can also be monitored using SPI.
A drought event occurs any time when SPI is continuously negative and reaches intensity where the SPI is -1.0 or less. The event ends when SPI becomes positive. Each drought event, therefore, has a duration defined by its beginning and end, and intensity for each month that event continues. The accumulated magnitude of drought is a positive sum of SPI for all the months within a drought event. PMD (2003) has analyzed the last drought episode in the country by using SPI as a criterion at 48 locations of the country with different time scales.

Water and Power Development Authority (WAPDA)

WAPDA is a federal agency responsible for collection of river flows, hydrometeorological data in the Indus basin and its catchments and for analyses of the impacts of any climatic changes in the river flows, storage-reservoir levels and groundwater levels in the country. WAPDA maintains the largest number of hydrometeorological and stream-gauging stations in the country. The processed information is made available to the concerned federal and provincial agencies through fax and on the website in case the country is facing a drought. They also provide such information to the Indus Rivers System Authority (IRSA), to the Federal Committee on Agriculture and, in addition, to the PMD and the drought-relief and mitigation-related agencies. In the recent drought, such information was made available to all the concerned parties on a daily basis through fax by the IRSA.

Provincial Irrigation and Drainage Authorities

These authorities are responsible not only for managing the canal deliveries but also for monitoring the canal diversions and distributing water within the canal network in the Indus basin. They are also responsible for sharing this information with all the concerned institutions in the country and work on an emergency basis during the drought periods. They also exercise the practices and schedules for managing the shortages in the canal supplies. During the drought period of 1998— 2002, provincial Irrigation and Power Departments

(IPDs) implemented comprehensive interventions including a) conservation of water releases from storage reservoirs during slack demand period and their reallocation during critical stages, b) canal water allocations on a priority basis to canal commands having brackish groundwater, and c) operating canals on revised rotations.

The District Governments

District Governments now include Departments of Agriculture, Livestock, Public Health, Revenue, etc. The field staff report to their respective district headquarters and the provincial departments any unusual changes due to a prolonged dry spell, i.e., reduced water availability for agriculture, livestock and for rural population. They also report such happenings to the District Governments, as these departments have been devolved and now their district staff are directly under the control of the district administration. The District Coordination Officer and the Nazim (District Public Representative) coordinate the information provided by various line departments and keep the provincial administration informed accordingly. The devolution system certainly has an edge to coordinate the monitoring information at the local level.

The major limitation in the monitoring of the drought is the integration of the hydrological, meteorological and socioeconomic information, as no single institution is responsible for the monitoring of drought in the country.

National Calamity Act

The Federal Government is responsible for developing a framework and undertake necessary mitigation measures and relief support for the social and economic revival of calamity-stricken areas (due to floods, droughts, earthquakes) and communities. The West Pakistan National Calamities (Prevention and Relief) Act, 1958, provides the required legislative basis and framework to counter the effects of various hazards. According to this Act, whenever a province or any part thereof is affected or threatened by calamities (droughts, floods, earthquakes, fire epidemic or any other disaster), the Government, by notification declares the whole or any part of the province as a calamity-affected area (GOP 1958).

This Act entrusts the provincial Board of Revenue to appoint a Relief Commissioner (which most of the time, is the senior-most member of the Revenue Board) for calamity-declared areas including the drought-affected areas. The primary role of the Relief Commissioner as outlined in the 1958 Act is reproduced as follows:

Collect field reports about losses of life, livestock and property and apprise the provincial and federal governments of these losses. Suggest compensatory fiscal amount for the calamity-affected areas, to the provincial and federal governments including postponement of land and other government taxes, tariffs, revenues, etc. Provide approved compensation to the affected population through District Relief Officers. The focus of the Act is therefore on relief measures.

Drought-Relief Measures

Whenever, under the National Calamity Act of 1958, any part of the country is declared as a drought-affected area, the federal, provincial and district governments have to respond to the situation by initiating a variety of relief and mitigation measures. The emergent relief measures for the severely affected communities include distribution of food, fodder, water, tents, blankets, medical supplies, and mobile medical and vaccination teams. Relief expenditures are supported through emergency budgetary allocations by both the federal and the provincial governments.

Depending on the drought severity, as suggested by the drought-monitoring and assessment, and resulting vulnerabilities, the Government of Pakistan may designate an area as either drought- affected or severely drought-affected. The relief plans initiated for the rehabilitation of these two categories vary. The government allocates more funds and undertakes extensive relief measures on a priority basis in the severely affected areas compared to the less-affected areas. Furthermore, in severely affected areas, the government may either waive off the land and other revenue taxes, postpone or even write-off the loan recoveries, may extend the special cash grants from the higher authorities (President, Prime Minister or Governor) along with the emergency relief supports of subsidized or free ration and water supplies, public and veterinary health facilities and fodder for livestock.

Problems observed in relief operations during the latest droughts in Baluchistan and Sindh included a) lack of a database on assessment and impacts of drought; b) lack of an appropriate analysis of the records and data collected; c) the attitudinal and behavioral problems; d) lack of commitment and devotion in relief operations and distribution of materials; e) lack of service orientation, especially in the health services; f) lack of awareness and culture of the relief camps; g) clear-cut role of the public and private-sector institutions and interdependencies; h) lack of public participation and media support; i) moral values of the society; and j) lack of coordination among the line departments.

Assessment of Required Relief

To estimate the worth of these relief-support programs as well as to prioritize the specific requirements of drought-affected areas, under the present legislative framework, the Provincial Relief Commissioners have the responsibility for drought assessment and to apprise the Federal and Provincial Governments of the required relief support. Most of the time, Relief Commissioners accomplish this task through the Provincial Board of Revenues and Revenue Departments.

To evaluate the impacts of drought on the livelihood of the rural and urban population and on the availability of water resources for domestic, water and irrigation purposes, extensive field visits and surveys are carried out by the Provincial Revenue Departments in drought-affected areas (GOB 2003). Similarly, the impacts of drought on health, sanitation and nutrition conditions in the drought-affected areas are also assessed through extensive field surveys and visits. In addition to the official field surveys and visits, NGOs and international donor agencies (UNDP, WFP, FAO, WHO) also conduct studies and surveys for the assessment of food and nonfood requirements in the drought-affected areas with an objective to provide information on the assessment of the severity of drought impacts. The Relief Support Programmes of donor agencies are structured on the basis of the requirements given by the government. Such surveys were conducted by FAO and UNDP during 1999-2002, which provided a realistic assessment of the damages of droughts and assessment of requirements for the Relief Support Programme (UN 2001; WB 2001; UNDP 2003).

The Board of Revenue of the Sindh Government carried out an assessment of the recent drought during 1999-2002 in the Sindh province while NGOs (Pattan, Action Churches together) and donor agencies (FAO, WFP, WHO) carried out independent surveys to evaluate the food, health and sanitation conditions in the drought-affected areas (PDO 2001; UN 2001; WB 2001, UNDP 2003).

The Bureau of Statistics, under the overall supervision of Planning and Development Department, Government of Baluchistan, carried out an assessment of the impacts of drought during 1998-2002 while the UNDP, FAO, OXFAM, and Islamic Relief carried out independent surveys in drought-affected areas of the province to evaluate food- and nonfood-supply assessments in the province.

Based upon these survey results, the Relief Commissioners of the concerned provinces rationally quantify and prioritize the relief-support measures, so that optimal compensation (both in cash and kind) for the affected communities can be ensured. To coordinate various relief measures for social and economic revival and rehabilitation of the drought-affected areas in the country as well as to maintain the liaison with the international donors, the Federal Government has established the institution including the following:

- Federal Drought Emergency Relief and Assistance (DERA) Unit
- Emergency Relief Cell (ERC) in the Cabinet Division of the federal government
- National Steering Committee

Drought Emergency Relief and Assistance (DERA) Program

For rehabilitation of the drought-affected areas of the country during the latest drought, the Government of Pakistan commissioned the DERA Program. For the execution of the activities of the DERA Program, funding was sought from the international donor agencies. The ADB and WB responded to the request of GOP and a total loan of US$140 million was approved (ADB contributed US$100 million and the WB contributed US$40 million). In addition to the loan, the government allocated US$20 million (mainly in the form of services) for the DERA Program. Out of a total DERA finding of US$160 million, the share of Sindh and Baluchistan provinces was 30% each, while allocations for Punjab and NWFP were 25% and 15%, respectively.

The focus of the program is on the provision of sustainable drinking-water supplies, water management and conservation for sustainable livelihood (agriculture and livestock), support for construction of roads and restoration of drought-affected orchards. The program also provides essential social services. Based on the source of funding, the DERA Program has been subdivided into the Drought Impact Mitigation and Recovery Component (DIMRC) and the DERA component.

The sectors identified for investment under WB funding (DERA component) in drought-affected areas of the country are irrigation, road construction, agriculture and rural water-supply schemes. However, the major thrust was on the provision of water supply, road construction and irrigation facilities, where 36, 35 and 23% of the total allocation under the DERA component were invested. In the Sindh province, the priority sectors were road construction and water-supply schemes for which 76 and 23% of the provincial allocations were utilized while, the situation was altogether different in the Baluchistan province, where irrigation was the top priority sector and where 54% of the provincial share was spent in the water sector.

The funding of the ADB (DIMRC) is mainly focused on water, agriculture, health, road construction and community welfare schemes in the drought-affected areas of different provinces. However, different provinces have different priority sectors. For example, the emphasis of the Government of Sindh is more on road construction in drought-affected areas, where 75% of the provincial DIMRC allocations were invested. In the Baluchistan province, the main thrust was on schemes related to water development. Installation of tube wells, rural water-supply schemes, construction of delay-action dams and improvement and renovation of karezes were accomplished in drought-affected areas of the province.

Federal Institutional Arrangements

The Emergency Relief Cell is a part of the Cabinet Division, Government of Pakistan. The history of this Cell dates back to 1970, when a catastrophic cyclone caused widespread devastation in the former East Pakistan. This Cell prepared a "National Disaster Plan" in 1974. The purpose of the Disaster Plan was to establish procedures, prescribe an organizational setup, fix primary responsibilities and support functions of the implementing agencies involved and standardize procedures for monitoring of the disaster operations. The plan embraces all disaster situations and envisages utilization of available resources (governmental, semigovernmental and nongovernmental). Being action-oriented, functional and flexible, the plan is capable of meeting disaster situations of various intensity as well as multiple contingencies. Despite being small, the Emergency Relief Cell is playing a substantial role in mitigation of disaster including drought:

- Provide assistance in cash and in relief materials to supplement the resources of provincial
- governments during droughts.
- Maintain liaison with international aid-giving agencies, volunteer organizations and donor
- countries for drought-relief measures.
- Administer the Prime Minister's Food Relief Fund at the federal level.
- Provide mobility including helicopters for rescue of the affected people and for relief operations.

To accomplish these responsibilities/operations in drought-affected areas the following infrastructure is available with ERC.

The Emergency Control Room of the Emergency Relief Cell goes into operation during the flood or drought season or other natural disasters. It maintains constant liaison with the Engineers Directorate of Pakistan Army, Federal Flood Commission, Pakistan Meteorological Department, Provincial Governments Relief Commissioners and Relief Officers. Daily situation reports are received from the drought-stricken areas through the Provincial Governments and the concerned Federal Agencies, and a comprehensive report is compiled depicting the latest position of the drought-affected area. Such reports help in decision making and in channelizing the relief operations.

Warehouse of the Emergency Relief Cell is located at Islamabad for stockpiling of essential relief items to be used during emergency situations. The Warehouse has basic nonperishable medicines and nonperishable goods (blankets, clothing and tents, etc.) that can be rushed to the affected areas at short notice.

A Deputy Director, located at Karachi, heads the relief Goods Dispatch Organization of the Emergency Relief Cell. This organization is responsible for making arrangements for receipt and dispatch of all relief goods from foreign and local agencies in the event of a disaster. The organization is also responsible for clearance and making flight arrangements at airports, seaports, refueling of planes, reception of crews, custom clearance and all other related formalities.

The Aviation Squadron of the Emergency Relief Cell maintains a fleet of six helicopters out of which three are nonoperational due to the nonavailability of spare parts. These helicopters are detailed for rescue operations during disaster and visits of relief officials to the drought-affected areas.

For the effective coordination and monitoring of the DERA program at the federal level, the Government of Pakistan has appointed Secretary, Planning and Development Division as the Federal Drought Coordinator. To assist the Federal Drought Coordinator, the National Steering Committee was established during November 2001. The steering committee is chaired by the Deputy Secretary, Planning and Development Division and has representation from various federal, provincial and international donor agencies. The Steering Committee has constituted the DERA Unit as its Secretariat, which is headed by the National Project Director. The primary function of the Steering Committee is to analyze and approve the relief schemes as submitted by the provincial DERA Units.

Provincial Institutional Arrangements

To coordinate, monitor and implement the drought-response strategy at the provincial level, the Relief Commissions were established under the instruction of the Federal Government. In addition to these, the provinces also have their own mechanisms to strengthen the relief-support activities within provincial jurisdictions. Similarly, to execute and monitor the DERA activities, provincial Steering Committees and Secretariats in the form of DERA Units have been constituted in all the four provincial headquarters. The specific institutional arrangements of the Baluchistan province (established during the latest drought) include the following:

- Relief Commission, Quetta
- Drought Crisis Control Centre (DCCC)
- Provincial Drought Management Committee (PDMC)
- Provincial DERA Unit, Quetta

The specific institutional arrangements of the Sindh province (established during the latest drought) include the following:

- Relief Commission, Karachi
- Provincial Steering Committee
- Provincial DERA Unit Karachi

The structure and role of the district-level institutional arrangements in the form of District Drought Control Committees have also been included in the DERA manifesto, but these are practically either nonexistent or inactive.

Political Aspects of Drought Declaration and Mitigation

Drought is not a sudden event but rather a process, which accumulates slowly over time in any region or area. As a result, it provides ample time for the state managers to undertake preemptive measures to minimize the vulnerabilities of the regions that are at risk. However, since governments have to initiate extensive programs at huge investment costs, they tend to ignore the issue at its emerging stage. Similar politics/tactics are being practiced in Pakistan, where economic stability is always questionable. The Government of Sindh, with an objective to avoid the rigorous pressure exerted by the extensive relief measures on limited fiscal resources, tries to ignore the dilemma being developed in the drought-affected areas. However, when the national and international media and NGOs highlight the sufferings in the drought-affected areas, and also the government perceives the green signals of donations from the international community, the initiatives are taken by the authorities.

The other interference of the politicians is to get their own districts declared as drought-affected to seek relief support. Therefore, politics also plays a critical role in the declaration of the drought-affected areas. The media and local NGOs also play a vital role in documenting the impacts of droughts and the assessment of the needs of the relief measures.

Political considerations also affect the measures, which are planned to reduce the distress and havoc of the drought-affected regions through several ways. First, if a drought-affected area belongs to a public representative who is from a ruling party, it may get relief support on a priority basis, even if the situation is not "that bad." On the other hand, if the drought-affected area is under control of a public representative of the opposition group, the relief may come late and be insufficient; and consequently, the disaster becomes inevitable. Similarly, some pressure groups within the government oppose relevant plans, which may alleviate droughts in the longer run. Strong opposition to the construction of new surface storage dams on the Indus is just one example.

Gaps in Drought Mitigation Gaps in Knowledge and Information

Impacts of Tube Wells on the Karez System

The traditional water-harvesting and management interventions used by the rural communities were sustainable compared to the introduction of the new technologies during the last three decades. For example, the karez was a traditional water-harnessing and irrigation system, which was sustainable for the development and utilization of scarce resources of groundwater in the fragile ecosystems of Baluchistan. The karez water-harnessing and irrigation system was designed using the local knowledge and skills to address the needs of the rural communities irrespective of their investment capacities. Therefore, the resource-rich and resource-poor farmers were equally involved in the development of karez and the system was aimed to have social equity, where water was available to all the households based on their contribution in the development of the karez system. With the development of deep tube-well technology and the provision of the National Electric Grid system in Baluchistan, the indiscriminate exploitation of groundwater through deep tube wells resulted in drying of karezes, and the resource-rich farmers started drilling deeper to ensure pumping of sufficient quantities of water under the conditions of continuous lowering of the water table.

The descriptive information on traditional and new technological interventions is available, but there is a complete gap of quantitative knowledge on how the new technologies affected the traditional and sustainable interventions like karezes. There is hardly any information available regarding the impact of new technologies in lowering of the water table and mining of groundwater in Baluchistan. Similar impacts were observed in the arid zones of the Sindh province, where indiscriminate use of groundwater by deep tube wells has led to the drying up of the shallow dug-wells and intrusion of saline water. There is a unique opportunity in Baluchistan to document the impacts of deep tube-well technology on the drying of karezes, which resulted in shifting the benefits of electric tariff subsidy to the resource-rich farmers. Baluchistan provides a unique opportunity to the Region in the assessment of the impacts of new technologies on the karez system. A comprehensive research study is needed to address this issue in a scientific manner.

Spate Irrigation and Groundwater Recharge

In Baluchistan, the sailaba (spate irrigation) system was historically given higher priority prior to the introduction of deep tube-well technology and the availability of electricity. The government is now providing a subsidy of Rs7 billion per annum on electric tariff for 14,363 deep tube wells, which provided opportunity to farmers to overexploit the groundwater for growing high-value crops. This resulted in the neglect of the sailaba system, which was very effective in spreading of floodwater and recharging the groundwater. Instead of the development of the sailaba system, delay-action dams were constructed by deploying huge financial resources to recharge the groundwater aquifer. There is a general consensus that the delay-action dams provide recharge to the shallow groundwater under very localized conditions. The contribution of delay-action dams for recharging the deep groundwater and at regional or basin level is still to be documented.

In general, little is known about the efficiencies of artificial recharge methods, which are a major issue in the Baluchistan province and the arid zones of the Sindh. Little is also known about the performance of water-harvesting and conservation methods under drought conditions of different extremity and about their impacts on the water-resources availability and sustainability

There have been studies to address the issue of sedimentation in the delay-action dams due to the heavy inflow of sediments in the floodwater. The concept of Leaky Delay-Action Dams was developed by the PCRWR, which reduces the speed of floodwater but allows slow release of floodwater downstream of the dam through outlets. This intervention is promising and might provide an effective intervention for the recharge of groundwater. However, there is a need to conduct a comprehensive study to document the techno-economics of delay-action dams in recharging the shallow groundwater in the localized and the regional contexts. Pakistan can share the experiences in recharging the groundwater in arid fragile environments with other countries in the region.

Research and Adaptations

There is hardly any institution having a mandate for R&D in the area of drought mitigation. The Arid Zone Research Center (AZRC), Quetta (an institution PARC) is involved in research related to the drought-prone areas, but their activities are limited to the agronomic, economic and management research for the khushkhaba areas and rangelands. The technologies developed by AZRC perform only if there is sufficient incidental rainfall; otherwise, crop harvests are not possible under drought conditions. The other limitation is that AZRC does not work at the scale of hydrological units, like river basins, and their research focuses primarily at the farm level.

In Pakistan's Indus basin, a number of water-management interventions has been developed over the last two decades. This includes water management at the farm level, especially the improved water conveyance and application technologies. But these technologies were not tested in the drought-prone areas. Thus there is an opportunity to test and evaluate these interventions in drought-prone areas of Baluchistan and Sindh provinces of Pakistan. In addition, Pakistan can also benefit from Iran's experiences in the area of drip irrigation, as it is much ahead of Pakistan. Reciprocally, Iran can benefit from Pakistan's experiences of watercourse improvement, laser leveling and furrow-bed irrigation systems.

Drought Preparedness and Mitigation

The knowledge and information for designing drought preparedness and mitigation measures are limited. The gap in knowledge is basically due to the disjointed efforts conducted by various institutions. Pakistan can learn from the countries of the region (e.g., India) that have been developing programs for drought mitigation.

Institutions

The institutional arrangements are reasonably well defined for the drought-relief activities, but there is hardly any institutional mechanism for drought preparedness and mitigation to address the long-term issues.
There is a lack of appropriate institutional arrangements and mechanisms to develop effective linkages between the public-sector institutions, nongovernmental organizations, the private sector and the civil society. Although these institutions worked in a more collaborative fashion during the latest drought period, such collaboration was limited to the so-called relief measures and never became part of their routine activities.

Presently, there is no comprehensive drought-mitigation infrastructure and strategy at the federal and provincial levels. Contrary to the well-established flood mitigation with adequate institutional arrangements, the drought-mitigation activities, by and large, are managed on an ad hoc basis. Institutional arrangements and their capacities are inadequate at the federal and provincial levels to effectively launch the early warning systems, preparedness and contingency plans, and rehabilitation measures, while such arrangements are nonexistent at the district level.

The major limitation in the monitoring of the drought is the integration of the hydrological, meteorological and socioeconomic information, as no single institution is responsible for the monitoring of drought in Pakistan.

Pakistan can learn from the regional experiences from Iran and India by sharing knowledge and information in the area of drought preparedness in relation to the institutional aspects. A regional study on institutional aspects is very much needed to share existing experiences and to learn how an effective institutional framework can be developed through a regional effort.

Policies

There is hardly any policy of the Governments of Baluchistan and Sindh for drought preparedness, mitigation and coping mechanisms. Only ad hoc measures were adopted after the recent drought, which persisted during the last 6 years (1998-2004).

Recently, the ADB initiated a Programme Loan for Baluchistan entitled "Baluchistan Resource Management Programme," which has four components: a) fiscal and financial management, b) public-service delivery, c) water-resources management policy, and d) private-sector development strategy. The formulation of the Water Resources Management Policy was well received by the Government of Baluchistan and other stakeholders because of the severe impacts of the prolonged drought (1998-2004) on the mining of groundwater and lowering of the water table.

The formulation of the Water Resources Management Policy would depend on the availability of reliable information regarding the availability and use of water resources, which is very limited at present. In Pakistan, information on the Indus basin is reasonable, but areas outside the Indus basin, including Baluchistan, have been neglected. Thus there is a gap in reliable information on surface water and groundwater. The impacts of drought were so severe that there is urgency for the reassessment of the resource availability.

Although there is an understanding for the need to formulate a policy there is hardly any commitment at the political level to enforce such a policy. Therefore, there is a need to initiate R&D activities to support the development of an implementable policy and a reforms agenda.

Everyone is convinced that lack of implementation is a major issue but hardly any systematic effort exists for the identification of mechanisms for the implementation of any policy or reforms. Therefore, there is a need to study alternative options for implementation of drought-mitigation and water-resources-management policy and reforms. Another issue is the impact of socioeconomics and political regimes on the drought preparedness and mitigation policies in the region, as the political system always affects technological and institutional efforts.

Options for Future Strategy

Technological

The APN study on the "Impacts of Climate Change on Availability of Water Resources in South Asia," including Pakistan indicated that extreme events like droughts and floods are going to become severer in the future. Considering the probability of having more frequent droughts in the future, there is a need to integrate the aspects of drought and water management by developing a strategy for research on "Drought and Water Management" in an integrated fashion. In fact, there should be one word giving the meaning of both drought and water management in arid environments, particularly those outside the Indus river basin.

Overall, in Pakistan, drought management should be part of the larger national water-development strategies and plans. WAPDA's comprehensive program of Water Resources and Hydropower Development has been designed to avert the impacts of droughts and desertification in the country on a longer-term basis by augmenting the existing canal-water supplies. The projects included in the Vision along with the site locations are presented in figure 3. The projects of Vision 2025 have been included in the Perspective Development Plan for the period 2001-2011. Work on several projects (Mangla Dam Raising, Rainee, Katchi and Greater Thai Canals) has already started. All the three mentioned canals will provide water to drought-prone areas (WAPDA 1987, 2001).

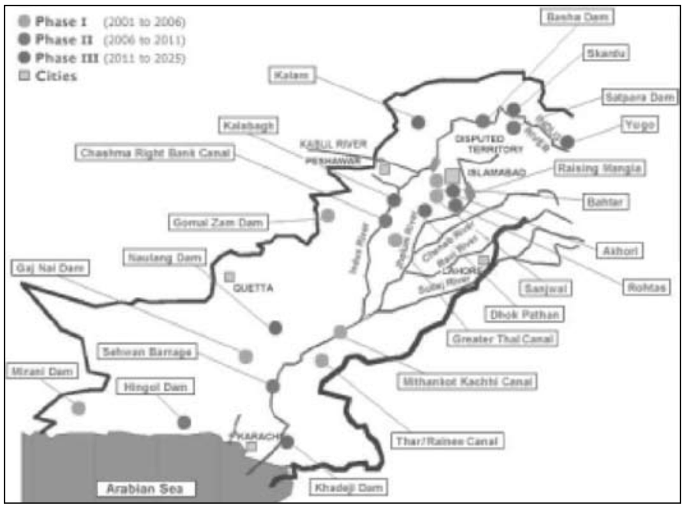

***Figure 3** : Location map of the water development projects envisaged under Vision 2025.*

The future strategy for technological development should depend on the realistic assessment of the surface-water resources in the fragile drought-prone environments, as the groundwater resources in these environments are limited. A good example is the Baluchistan province where the groundwater resources constitute 4% of the annual available water resources. The other 96% is available from the surface-water resources. Therefore, emphasis should be placed on surface water, out of which, around 30% is available from the Indus basin and 66% from the floodwater. Out of the floodwater, around 30% is utilized and the balance 70% is lost unutilized. Thus the potential source of development is the floodwater, which could be, and is, presently being used for the sailaba area, dependent on spate irrigatioa The situation is similar in arid zones of the Sindh province. The other aspect worth considering is the risk involved in the availability of floodwater due to low rainfall. There is a need to conduct research for the development of a strategy for technological development with active participation of water users and link spate irrigation with interventions related to recharge of the groundwater. The unutilized floodwater available for potential development in Baluchistan is around 12 billion m3, which is equivalent to the designed live storage capacity of the Tarbela dam.

Presently, the Irrigation and Power Department is actively involved in the construction of delay-action dams for recharging the groundwater. The effectiveness of these dams is questionable from two standpoints: First, whether the delay-action dam contributes significantly to recharging the shallow groundwater or deep groundwater. Second, what is its contribution at the local and regional levels? The Government of Baluchistan is stuck with making a decision on the effective ways of recharging the groundwater.

In summary, the strategy for technological development in Baluchistan and arid areas of Sindh should be based on the assessment of the potential resources available for development through integrating activities of spate irrigation with the objective of spreading of floodwater to increase the command area and recharging the regional groundwater resources.

Institutional

The institutional aspects of spate irrigation and regional groundwater recharge are very complex and include water user institutions, line departments, district governments, research institutions, policy institutions and public representative institutions.

The major problem is that the Irrigation and Power Department is engaged in, and will continue to handle, spate irrigation and groundwater recharge activities in traditional surface irrigation approaches. In fact, there is a need to document the traditional systems of spate irrigation and then evolve improvements with active participation of the water users' institutions prevailing in the area. The major issue is how to make the traditional water user institutions sustainable in terms of both capacity and financial autonomy.

The institutional development strategy should revolve around the existing institutions and the policies related to the participation of users in the planning, appraisal, design and implementation of the schemes. There is also a need to review the existing structure and mandate of the public-sector institutions, especially after the devolution at the district level; the role of the provincial institutions was never reviewed. This is also a handicap in the development of the district governments and the implementation of the devolution agenda.

The introduction of the devolution was an effort in the right direction, but due to the lack of reorientation of the provincial institutions and identification of the revised role, the whole experiment of devolution is at stake.

Most of the line departments have been devolved under the district government, except the Irrigation and Power Department. The basin-wide approach is always preferred to the sustainable management of water resources. But all the other line departments are organized under the boundaries of the district administration. Therefore, the conflict between the administrative and hydrological boundaries has to be resolved to achieve the overall objective of sustainable resources management under drought conditions.

In summary, institutional development is needed to have active participation of water user institutions in the management of water resources. This would be achieved through assigning specific roles to the water user institutions and reorientation of the provincial line departments. There is also a need to bridge the gap between administrative and hydrological boundaries.

Policy

In the policy arena, there is a need to have IWRM and Drought Mitigation Policy for Baluchistan and Sindh provinces of Pakistan. The ADB, under the Baluchistan Resource Management Programme, has started formulating the Policy Paper on IWRM in which drought-mitigation measures will also be considered. But there is complete lack of support information and knowledge to develop an efficient policy and reform agenda. The following aspects should be considered as part of the proposed strategy:

- Review the existing policies related to drought and water management and identify the policy research areas.
- Identify the potential national collaborators for initiating the policy research covering areas like reassessment of the resources, basin-wide management plans, implementation of the drought-mitigation and water-management interventions, institutional arrangements, participation of water user institutions including gender participation, etc.
- Presently, the emphasis of the policy is on providing subsidy on electricity tariff, infrastructural development like the construction of surface irrigation schemes and delay-action dams, whereas very little emphasis is placed on the management of the resource.
- This resulted in mining of groundwater and lowering of the water table.
- There is a need to formulate policies which link the development of the resource within the framework of the IWRM and drought mitigation.
- The basin approach is essential for the management of the resource; therefore, policy research is needed on how to bridge the conflict between the hydrological boundaries and the administrative boundaries.
- A poverty reduction focus is essential along with the management of the resource. Therefore, research is needed on how the poor are located within the existing ecosystems covering the canal irrigated area, minor perennial irrigation schemes, tube-well irrigation, sailaba and khushkhaba. An interesting aspect is that electricity subsidy is given to the 50% of tube well owners who are operating their tube wells on electricity, whereas the balance 50% tube wells are being operated on diesel fuel. Thus diesel operated tube well owners are deprived of any subsidy. Another aspect is that the poorest of the poor live in the sailaba and khushkhaba areas, which are completely neglected. Drought-related policies should help in poverty alleviation in these areas.

One critical issue is the high O&M of the water schemes for both water supply and irrigation. The concept of hading over of the schemes to the community fails because they cannot manage these schemes due to the high O&M costs. In fact, the community was never asked what type of schemes they wanted and what level of O&M they could manage. There is a need to review the existing policy of infrastructure development in drought-prone areas.

Conclusions and Recommendations

The existing system of monitoring drought and its impacts on various sectors is weak. The dissemination and sharing of the available information to the civil society and between and across government departments and with organizations outside government system are limited. There is a need to develop a policy for the access to information related to drought and water management. Such information databases themselves are limited at present. A similar situation exists at the regional level. Sharing and exchange of information regarding drought monitoring and impact assessment are also limited among the countries of the region. India is ahead in this regard and Pakistan can learn from their experiences. Similarly, exchange of information and building joint programs between Pakistan and Iran would help the two countries as the climate and environment are similar in both countries (at least in Baluchistan and adjacent areas of Iran).

Both target areas (provinces) considered in this document have limited water resources in areas outsides the Indus basin. Still they do not make efficient use of the available resources. Farmers are not aware of actual crop water requirements and irrigation-scheduling practices are still largely based on the amount of water available with the farmer and the situation of the farm. Farmers tend to overirrigate to cover the unleveled fields. Efforts are needed to help farmers in efficient conveyance and application of pumped groundwater. The water-management technologies developed in the Indus basin regarding conveyance and application of water at the farm are very promising as Pakistan was ahead of the countries in the region. Even then such technologies were hardly tested and adapted in the drought-prone areas. Pakistan can provide a unique opportunity to share the experiences of the watercourse-improvement program, laser leveling, furrow-bed irrigation, skimming wells and salinity management. Similarly, Pakistan can learn from India and Iran in the area of drip and sprinkler irrigation systems as both these countries are ahead in this regard. A regional research and development program for drought and water management seems justified for exchanging experiences and knowledge and building future activities.

Farmers should be encouraged and motivated to use indigenous water-harvesting technologies for sailaba and khushkhaba areas. There is a need to understand the traditional systems of sailaba and khushkhaba and suggest improvements within the existing framework instead of introducing conventional surface-irrigation schemes. The use of local knowledge and wisdom is essential along with active participation of local water user institutions. Pakistan is ahead of the region in developing the sailaba irrigation as such systems have been in place since 3000 BC. These systems of water spreading if integrated with recharging the groundwater can provide cost-effective intervention for mitigating the drought impacts. The spate-irrigation development provides a workable option for the normal years and such systems do not provide water during droughts. Thus the population has to migrate from these areas during the drought. Therefore, provision of water-storage dams can provide a source of small-scale irrigation for the drought periods so that rural communities can stay in these areas. Furthermore, such dams can also provide a source for supplemental irrigation. Provision of water for high-value agriculture in sailaba systems would be the ultimate goal of mitigating the impacts of drought. The experiences of Iran under the Program of Jihad-a-Sadindgi are highly valuable for other countries of the region to learn how the rural communities and the experts were motivated to construct small storage dams.

Due to the excessive exploitation of groundwater, coupled with successive droughts, the water tables in different parts of Sindh, especially in Baluchistan, have declined considerably . In Baluchistan, even karezes (traditional groundwater irrigation systems have dried up. This overexploitation of the resource has caused devastating impacts on drinking water supplies for urban and rural populations. For conservation of the resource, the government needs to develop appropriate policies to effectively manage and monitor groundwater development and use. Steps should be taken for the revision and enforcement of water laws. Communities should be directly involved in the campaign of recharging the aquifers and in the conjunctive use and management of surface water and groundwater resources. Pakistan's Indus basin experiences of conjunctive use of water have to be used and adapted in the drought-prone areas of Baluchistan and Sindh provinces. Such experiences if translated for the nonirrigated areas can provide excellent examples for the countries of the region.

The use of efficient irrigation methods, farm layout, balanced use of fertilizer and pesticides, and integrated nutrient management remain limited and is one of the key factors underlying low productivity in Sindh and Baluchistan. There is a need to arrange demonstrations by the WUAs to disseminate a full range of improved water-management and water-use-crop-production practices to the WUA members. Training of WUA members would be an essential element of the whole program. A program of breeding and selection of crop varieties, which can extract water from a deeper level should be established. Such varieties coupled with water management can revolutionize sailaba areas. The character of the sailaba system is that 1-2 irrigations of 1-1.5 m depths are applied to mature the wheat crop. The soils are rich in nutrients and farmers are not using any chemical fertilizers, as every flood brings fresh silt of 5-7 cm in depth. These ecologies are therefore potential locations for organic farming in the region.

Farmers should be encouraged, motivated and trained in the adoption of efficient water-use technologies such as sprinkler and drip irrigation, laser leveling, raised-bed planting, rainwater harvesting, watercourse lining and water-storage tanks, which have proven successful in different arid environments of Pakistan. Involvement of the private sector in the provision of services to farmers is the only workable option, as the public-sector institutions are not tuned to provide services in this regard.

A drought-mitigation plan is essential for the drought-prone districts of the Sindh and Baluchistan provinces. This should also include climatic change impacts on the availability of water resources and to develop coping mechanisms to address the drought impacts. In fact, such a plan has to be integrated in the overall perspective development plan so that all the sectoral development plans should look into drought-mitigation aspects in their routine development activities.

Presently, there is no comprehensive drought-mitigation infrastructure and strategy at the federal and provincial levels. Contrary to the well-established flood mitigation with adequate institutional arrangements, the drought-mitigation activities are, by and large, managed on an ad hoc basis. Institutional arrangements and their capacities are inadequate at the federal and provincial levels to effectively launch the early warning systems, preparedness and contingency plans, and rehabilitation measures, while such arrangements are nonexistent at the district level. In fact, this is the weak area in the region as a whole. This justifies a regional initiative to evaluate the existing institutional setup and mechanisms for drought mitigation and build an effective structure and mechanisms, which can be adopted by the countries of the region.

To mitigate the drought impacts, it is essential to formulate and adopt a National Drought Policy on a priority basis. The suggested guiding principles for the formulation of the National Drought Policy include the following:

- Favor preparedness over insurance, insurance over relief and incentives over regulations.
- Set research priorities to address the needs of rural communities and urban households considering the effectiveness and limitations of the existing coping mechanisms.
- Coordinate the activities of the drought-mitigation services at the federal, provincial and district levels.
- Participation of public representatives and the civil society is an essential element of any policy.

- A consultation and communication strategy should be formulated while developing the National Drought Policy. The purpose is to build understanding and ownership of the Policy by all the stakeholders.
- Sharing and exchange of experiences from the countries of the region having similarities.

Preparedness, which includes drought planning, plan implementation, proactive mitigation, risk management, resource stewardships, consideration of environmental concerns and public education should be the elements of the new policy. This policy would require a shift from the current emphasis on ad hoc relief measures to the proactive risk management.

For implementation of the National Drought Policy, there is a need to establish an apex organization for the planning, coordination and monitoring of the policy interventions at the federal level. This organization may be entrusted with the responsibility for providing an enabling framework to the provincial governments, where they are motivated to establish a similar organizational setup at the provincial levels to provide linkages and coordination among the line departments and the district governments. A consultant input will be required to prepare the outline for the proposed organization at the federal and provincial levels. At the district level, a District Drought Mitigation Committee would be required to implement and monitor the programs as envisaged by the federal and provincial governments.

There is a need to develop regional R&D Program for Drought Mitigation and Water Management through active involvement of international organizations and NARS. It should be aimed at a) sharing and exchange of existing knowledge and information between participating countries, b) studying the policy and institutional aspects under each participating-country National Program and encouraging testing and adoption of successful interventions in the participating countries, and c) evaluating the impacts of socioeconomic and political changes on the policies of drought and water management in the region.

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Drought Management in Sri Lanka

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Climatic Conditions in Sri Lanka

Sri Lanka is a humid tropical island, situated in the path of two monsoons, the south-west and north-east monsoons. Location, climate and topography are the main factors that influence precipitation and surface water availability which causes to disasters such as floods, landslides and droughts during extreme events.

The average annual rainfall over Sri Lanka is approximately 1861 mm. The rainfall ranges from under 1000mm in the driest parts to over 5000mm in the wettest parts of the country. The rainfall pattern divides the country into two main climatic regions the wet zone and dry zone. The wet zone receives an annual average rainfall of about 2,400mm and the dry zone's annual average rainfall is around 1450mm. These two zones are generally demarcated at the 2000 mm annual average rainfall isohyets. Approximately 25 percent of country lies in the wet zone. The south-eastern and north-western areas are the driest parts of the island with annual rainfall below 1000 mm. The spatial distribution of rainfall in Sri Lanka during different rainfall seasons shows a wide variation. The south-western sector receives more rain during the south-west monsoon while the north-east monsoon brings more rain to the northern and eastern sectors. During the inter-monsoonal periods rainfall is experienced over most of the parts of the island. However, the quantity of rain received over the northern and eastern parts of the country during the north-east monsoon is less than the amount received over south-west during the south-west monsoon. Therefore a major part of the country is dry relative to the south-western region.

Sri Lanka's climatic year is divided in to four seasons and the contributions made during each of these seasons are given below in Table 1 based on the annual rainfall for the reference period 1961-90.

***Table 1**: Average Rainfall during different rainfall seasons for 1961-1990*

Rainfall Season	Period	Average Rainfall mm	% of Annual Total
First Inter Monsoon	March – April	268	14
South West Monsoon	May – September	556	30
Second Inter Monsoon	October – November	558	30
North East Monsoon	December – January	479	26
ANNUAL		**1861**	**100**

The first inter-monsoon is concentrated on the south-west slopes of the country, while the second inter-monsoon impacts the north and north-east. The second inter-monsoon period of October November is the wettest of the four seasons throughout the entire island.

The mean annual temperature values in Sri Lanka show largely homogeneous temperatures in lowlands and rapidly decreasing temperatures in the highlands. In the lowlands (up to an altitude of 100-150meters) the

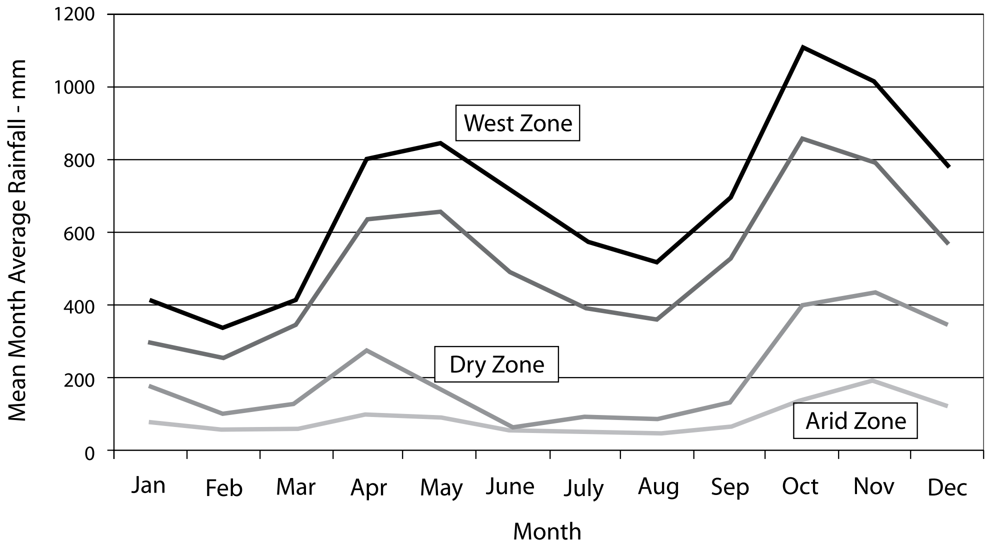

Figure 1: *Mean Monthly Average Rainfall (1960-1990) in selected stations in wet zone, dry zone and arid zone*

mean annual temperature varies between 26.5 – 28.5 0C with an average annual temperature of 27.50C. In the highlands, the temperature falls quickly as the altitude increases, approximately at a rate of 2 0C every 300 meters. At places with high altitude in the island the mean annual temp ranges from 14.7 – 17.1 0C.

The annual pan evaporation values within Sri Lanka indicate that there is a significant spatial variation, and the values vary between 1900 and 795 mm per year. The monthly average evaporation over a year shows a wide spatial variation ranging from 2.72 to 4.75 mm per day. The average annual reference crop evapo-transpiration at several stations in the country indicates that the values vary between 2.4 mm/day and 5.2 mm/day.

Water Resources and Effect of Drought to Water Users

Surface water

There are 103 distinct river basins out of which 16 are wet zone rivers benefitted from south-west monsoon rains. 26 major river basins are in the dry zone receive water from north-east monsoonal rains. In these river basins there are water storage reservoirs to collect water for irrigation and other purposes.

Water storages

It is estimated that there are about 13,000 manmade reservoirs in the country. Out of these, 80 are classified as large dams. There are about 85 major diversion structures in Sri Lanka. In addition, there are about 7600 functional small village tanks in the dry zone and 12,950 small scale diversion weirs (anicuts) in the wet zone and dry zone. The command area of these small tanks and anicuts is less than 80ha. These reservoirs provide several services to rural communities in the dry zone such as water for agriculture, drinking, domestic, livestock and sanitation etc. In addition these provide environmental sustainability and support to the ecosystems

The small tank or village tank systems were constructed in ancient times and functioned as centers of ancient village settlements. The center of the dry zone village is the tank and houses are grouped on one or both sides of the tank on relatively higher elevation around the tank bund. The wells for domestic water, which tap the shallow ground water table, are located within this homestead area. The irrigable land below the tank bund is located along the main axis of the valley. Rain-fed upland crops are grown on the unirrigable slopes of the upland under a system of shifting cultivation. A summary of the number of both operational and abandoned small tanks in provinces in the dry zone is given in Table 2 below.

From this table it can be seen that the highest number of operational tanks and abandoned tanks are in the North Central Province and North Western Province. Most of these small tanks fall under cascade systems, a connected series of tanks organized within the catchment of the dry zone landscape. These small scale tank cascade systems, constructed in ancient times, could be considered as unique irrigation systems. Through proper land and water management practices within these cascades, the drought disasters could be mitigated.

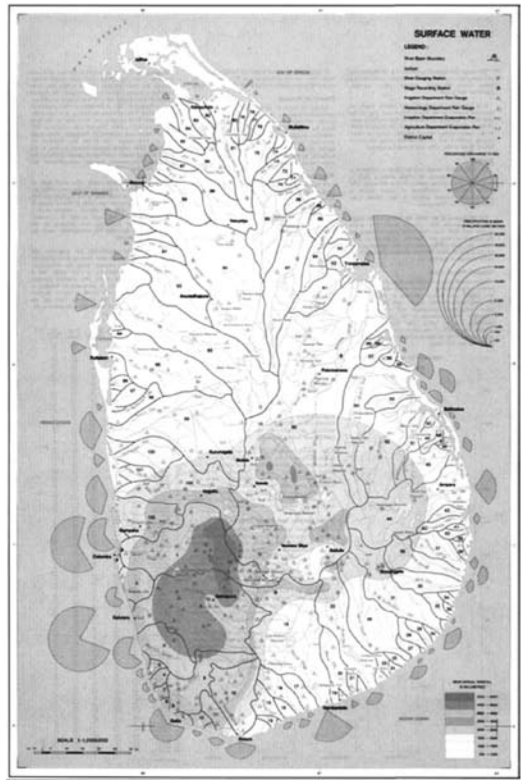

Figure 2: *Water Resources Map of Sri Lanka*

The North Western and North Central provinces are highly vulnerable for droughts and the risk also high as the population is high compared to other provinces. Therefore it is important to concentrate the rehabilitation and renovation of the small village tanks as a drought mitigation measure.

Table 2 *: Number of operational and abandoned small tanks*

Province	AreaSq km	Operational Tanks	Abandoned Tanks	Total
North	3709	608	816	1424
North Central	10,365	2095	1922	4017
North Western	7760	4200	2273	6473
Southern	2849	653	757	1410
Uva (Lower part)	2901	16	543	559
Eastern (south of Mahaweli)	3885		1017	1017
Eastern (North of Mahaweli)		48	425	473

Source: *Small tanks in Sri Lanka, IWMI Publication*

Ground Water

The ground water resources in Sri Lanka are considered to be lesser compared to surface water resources. The ground water is widely used for domestic, small scale irrigation, industrial and other uses. The demand for ground water development is especially for domestic water needs. However, the coastal sand aquifer area in the north-western region is being extensively used for agriculture.

Predominantly in the dry zone, shallow ground water that occurs under the small tank cascade systems is now being subjected to sever stress of over extraction. The use of this ground water through large diameter dug wells or agro-wells for growing high value cash crops has increased at an accelerated pace over the last decade. If it is over exploited it could lead to long term desertification which would lead to long period drought disasters in these areas.

Water Uses: Water for Agriculture

The total cultivated area in Sri Lanka had been estimated as 1.86 million ha of which about 632,000 ha are irrigated. Crop production systems in Sri Lanka are commonly categorized in to three main groups namely, major schemes, minor schemes and rain-fed cultivation systems. The area under irrigation had been increasing during last century, especially after 1950 with the renovation of ancient irrigations schemes, construction of new irrigation schemes and also with the rapid development in the Mahaweli River basin. The total extent available for rice cultivation is nearly 742,000 ha in year 2003. These total paddy lands are cultivated under major irrigation schemens, minor irrigation tanks and rain-fed cultivation as per the details shown in Table 2.

Table 3*: Cultivated Extends*

Cultivation System	**1980/81**		**2003**	
	Extent - ha	%	Extent - ha	%
Under Major Irrigation Schemes	245,550	36	335,026	45
Under Minor Irrigation Schemes	171,066	26	177,433	24
Rain-fed cultivation	253,078	38	229,257	31
	669,693	**100**	**741,716**	**100**

Sri Lanka has two cultivation seasons associated with the two rainy seasons, the south-west monsoon period from May to September and the north-east monsoon from December to February. The two seasons are called as Maha and Yala respectively.

Water Uses: Water for Hydro power

Hydro power generation contributes heavily to the Sri Lankan power generation. In 1989 the contribution from hydropower to electricity generation was 98% where as it has decreased to 41% in year 2003. In 2009, the hydropower generation capacity was 1379 Mw which is 51.4% of the total capacity of 2, 683 Mw. In the same year 3, 884 Gwh, which is 39.3% of the total generations was generated through hydro power while total production was 9, 882 Gwh. There are 13 hydropower stations located in the wet zone in the country which totally depend on the south-west monsoon rains. In year 2001 drought, most of these hydropower reservoirs had water deficits where the government had to cut the power supply during August September period for 2-3 hours.

Drought conditions have a significant impact on the power generation and hence on the national economy. On the other hand with the introduction of coal power generation, there may be possibilities to use hydro power generation as a supplementary power generation method if agriculture sector has a comparative advantage over the power generation.

Water Uses: Water for Drinking

The urban population gets their domestic supply from water supply schemes developed by National Water Supply and Drainage Board. In the wet zone the water is extracted from major rivers. For example the capital city of the country, Colombo city is supplied water extracted from Kelani River. Even in the wet zone during dry spells the water levels in the main rivers also deplete causing water shortages for the urban populations. There had been few incidents in the past where water cuts imposed due low levels of the rivers. The other population in the wet zone use dug wells for domestic purposes where the water availability totally depends on the ground water level.

The water supply schemes in the dry zone extract water from major irrigation reservoirs. In year 2001 drought, all the minor tanks and all major irrigation reservoirs were dried up resulting severe drinking water problems in the entire district. The rural community in the dry zone mainly depends on dug wells, agro wells and sometimes from village tanks etc.

Droughts in Sri Lanka

From the ancient times, Sri Lanka has experienced several severe drought conditions according to the historical records. Main causes for such situations are delays or failures of the monsoonal rains, less precipitation than the annual average, high temperatures and evaporations etc. In recent past severe droughts have occurred in years 1966 drought from May-September, 1967 drought from May to September, 196-77, 1980, 1981, 1983, 1988-89, 1995-96, 2001, 2004 resulting considerable losses to the economy and livelihoods. With the experiences on recent past droughts, it has been seen that some parts of the country experienced drought conditions regularly. Even though detailed studies have not been done on the occurrence of droughts, by looking at the past records, the frequency of occurrence of the significant drought incidents could be estimated as one in ten years.

According to the Desinventar database of historical disaster events maintained by the Disaster Management Centre, almost all parts of the country have experienced a drought condition within last thirty four years. 12,507,265 people have been affected by drought in last thirty four years and on average 27 million rupees are being distributed among the affected communities as drought relief annually. An average of 11,077 hectares a of paddy land get destroyed due to unavailability of water every year and a vast extent of other crops get affected by drought resulting in a huge economic loss to the country. As far as the frequency of occurrence and the number of people getting affected are concerned, drought can be identified as the biggest disaster in Sri Lanka.

Drought prone areas

Drought occurs annually in certain parts of the country in different scale. The entire dry zone which includes an intermediate zone and an arid zone is vulnerable to droughts. Out of the total 25 districts, 15 districts are in the dry zone. The population in the dry zone area is ....percent of the total population whose main

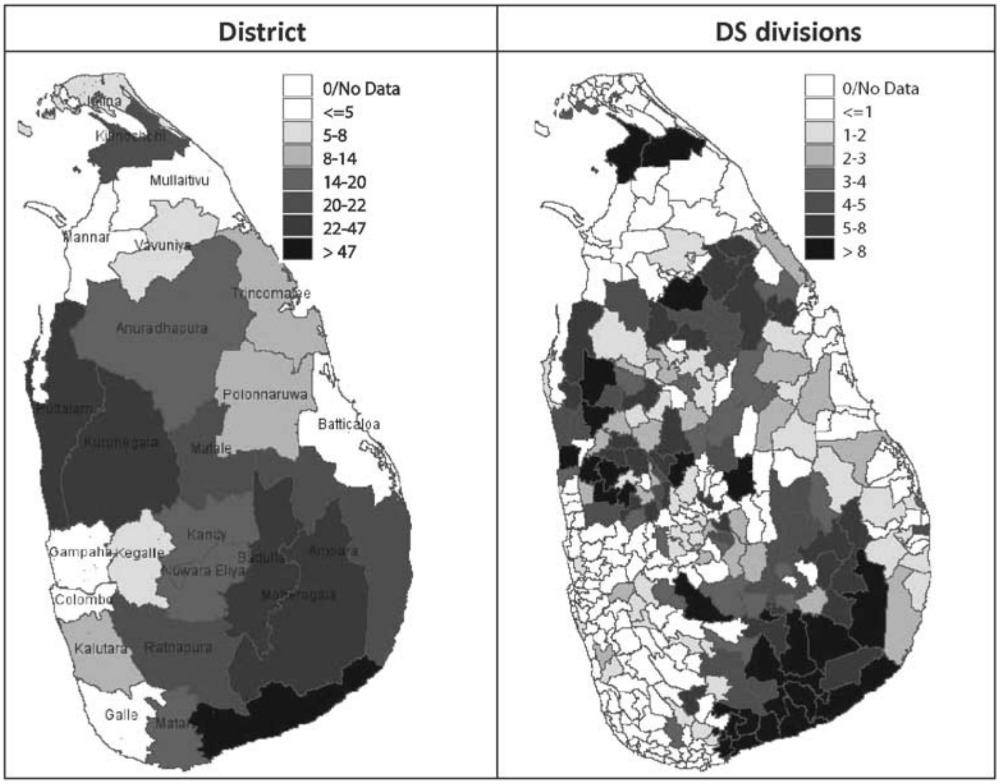

Figure 3: Map of Drought Affected Districts and Divisional Secretary Divisions (based on DisInventra database)

livelihood activity is agriculture. Drought makes a very perceptible impact on these population that are largely dependent upon agriculture and related occupations for their livelihood. As crops are adversely affected by droughts, loss of agricultural income as well as loss of employment makes lot of difficulties to this rural population.

The following figure shows the drought affected districts and divisional secretary divisions based on the DisInventar database. In Sri Lanka there are 25 districts, 325 divisions and nearly 15,000 Grama Niladari divisons. The highest affected areas are the two arid areas in south-eastern and north-western parts of the country.

Droughts in 2001 and 2004

Year 2001 drought affected almost entire country. The Hambantota district which is an agricultural district was the hardest to suffer. But several other districts such as Monaragala, Puttalama, Kurunegala, Ratnapura, Badulla and Ampara were also severely affected. The following Table No 4 shows the people affected in different districts. Months of no rain resulted in starvation for many poor families who do not have other means of livelihood. Government institutions, private organizations, schools and people were participated in the relief distributions by donating mostly water and dry rations.

Out of the seven districts all except Ratnapura district are lies in the dry zone. Some areas in Ratnapura district lies in the intermediate zone but the percentage affected is high.

***Table 4**: Effect of drought 2001*

District	Total Population	Number of people affected	People affected as a percentage	Remarks
Hambantota	525,087	411,228	78.3	
Monaragala	761,236	162,700	21.4	
Puttalama	492,500	167,172	33.9	
Kurunegala	1,452,362	352,380	24.3	
Ratnapura	1,007,525	281,229	27.9	Wet zone district
Badulla	782,191	140,010	17.9	
Ampara	581,479	62,516	10.8	
TOTAL			**28.2**	

The worst affected district was Hambantota which is in the south-eastern part of the country and falls in to the arid zone. There are eight reservoirs and eleven irrigation schemes in the district and all eight reservoirs were dried up due to the drought. The main reason for drought was lack of rainfall within the district and also in the upper catchments of the reservoirs due to failure of south-west monsoon. In addition to major reservoirs, there are many minor tanks (village tanks) in Hambantota where all these tanks also totally dried up.

Due to the failure of south-west monsoon the reservoirs in the central hilly area which use for hydro power generations also not filled. This affected badly to power generations, where in early August government decided to have one and half hour power cuts. But in end of August, again the government extended the power cut to two and a half hours. This affected the entire country, each household in Sri Lanka.

The drought 2001 is a good example for meteorological, hydrological and agricultural drought. Even though this situation has not yet been analysed or categorized to identify the severity of the drought incident.

Similarly in 2004, due to unfavorable changes in the weather pattern during the period September to December 2003, many parts of Sri Lanka received exceptionally low rainfall. Rainfall recorded in December at the Meteorological stations at Hambantota (0.7mm), Colombo (6.6mm), Kurunegala (10.8mm), Nuwara Eliya (19.5mm)and Batticaloa (83.1mm) were the lowest ever recorded for the month since 125 years. October and December rainfalls were exceptionally below normal almost all over the country.

Definition of droughts and related terminology

Sri Lanka mainly experience droughts due to failure of monsoonal or inter-monsoonal rains. Droughts occur annually in certain locations in the dry zone and people suffer due to unavailability of water for drinking and domestic purposes. Several small scale drought mitigation projects have been conducted in some of these areas by the government organizations as well as INGOs. But there is no proper drought mitigation plan nationally or regionally at district levels.

To manage droughts it is important to study the types of droughts commonly occur in Sri Lanka. Some areas in the dry zone there are large number of major irrigation reservoirs and minor tanks which can be used to mitigate the drought conditions through proper water management and land management practices.

Definition of droughts

In Sri Lanka, no methodologies are used to categorize the droughts. Even though there are several internationally agreed definitions for droughts based on meteorological conditions, hydrological conditions, agricultural situations and economic factors there is no general consensus for proper definition for drought which is applicable to Sri Lankan context.

It has been seen that there are some simple working definitions used by different researchers, scientists as listed below which need some clarifications.

***Table 5**: Definitions of some commonly used terms in Sri Lanka*

Term	Definition	
Absolute Drought	0.01 inch (0.02mm) of rain or more is not recorded on any day during a period of at least 15 consecutive days	Department of Meteorology
Partial Drought	For a period of at least 29 consecutive days, the mean daily rainfall does not exceed 0.01 inch (0.02)	
Dry Spell	Any period of at least 15 consecutive days to none of which is credited with 0.04 inch of rain or more	
Meteorological Drought	Prolonged deficiency of rainfall. If any region of the country receives less than 75 percent of its normal rainfall during the Maha or Yala seasons, then that region is said to be affected by drought	Amaradasa 1997
	If rainfall is less than four inches within a period of three months, it is considered as a drought	Wickramaarachchi 1963
	When reservoirs are depleted and the crops are threatened by a lack of water	-Do -

These different definitions high light that it is very essential to have clearly defined definitions for the different types of drought which will help decision makers and also planners for future planning activities.

Simple definitions of three types of droughts are as follows.

Meteorological Drought

This type of drought occurs when there is a prolonged period of below average precipitation, which creates a natural shortage of available water.

Hydrological Drought

This type of drought occurs when water reserves in aquifers, lakes and reservoirs fall below an established statistical average. Again, hydrological drought can happen even during time of average or above average precipitation, if human demand for water is high and increased usage has lowered the water reserves.

Agricultural Drought

This type of drought occurs when there is not enough moisture to support average crop production on farms. Although agricultural drought often occur during dry, hot periods of low precipitation, it can also occur during periods of average precipitation when soil conditions or agricultural techniques require extra water.

Characterizing droughts

Drought is a three dimensional phenomenon that can be characterized by its severity, intensity, duration and geographic extent. There are different drought indices which can be applied to categorize droughts.
Severity of a drought

It is understood that the severity of a drought is a function of several factors such as duration, intensity, damages due to drought, people affected etc. The severity of drought could be categorized as extreme, severe, moderate, mild etc under all types of droughts ie meteorological, hydrological, and agricultural droughts. It is important to identify some suitable and adaptable indices for categorization.

Duration of drought

The period of a drought could be varying and there should be a clear understanding on the commencing period of drought. Past experiences have shown that the average drought period ranges from just one month of every small water deficit in the wet zone areas, two to five months in the intermediate zone and six to eight months in the dry zone. For example, the 1966 drought was experienced in the northern half of the island and in extreme southeastern region. In Mannar in north had a 118 day spell of drought from 1st May to 26th August. Then, after a break of ond day on the 27th there followed another partial drought which lasted 32 days from 28th August to 28th September. Therefore when defining the duration of a drought, the commencing of the dry spell period, the ending date etc need to be understood properly.

Intensity of a drought

In Sri Lanka, the intensity of drought is highly variable from one ecological zone to another. In 1966 drought, Mannar district in the northern part of the country recorded only 58 mm of rainfall during five months against an average of 101mm. The Puttalama district in north western part of the country experienced only 32 mm of rainfall during the four months from May to August while its average for the four month period is 160mm. When defining the intensity of drought, the variation or the shortfall of rainfall from the standard averages is to be considered.

Drought Management

Ancient Drought Management Methods

Villages in Sri Lanka grew up as small settlements around village tanks. Some of these villages have been in existence for more than 2000 years. The construction, maintenance and operations or water management of these small tanks was the responsibility of the village community. The village administration systems also evolved around the management practices associated with the village tank.

As drought was a frequent phenomenon from the ancient times, ancestors have developed one of the most advanced hydro engineering marvels of whole world – ancient tank system in Sri Lanka. Entire social life cycle was determined by the availability of water for agriculture in ancient times and hence methodical systems were developed to ensure that drought adaption measures were sustained properly. It is estimated that there is one tank for every square mile of the ancient population centres of the country. Most of them have now been abandoned but still a significant amount of tanks are in use and the government and other development agencies are taking various steps to rehabilitate the abandoned tanks. Sri Lankan government in post independence era has taken number of steps to reduce the impacts of drought. New irrigation and resettlement schemes such as Gal Oya, Uda Walawe and Mahaweli, new domestic water supply schemes, developing drought tolerant crop varieties, promotion of water efficient cultivation practices etc can be cited as highlights of the different programmes undertaken by the respective regimes to uplift the living conditions of drought affected communities.

Basically, infrastructure developments as well as improvement in management systems have contributed significantly to lessen the drought impact on Sri Lankan society but still the issue surfaces seasonally. The roots of the problem can be traced to meteorological issues as well as the governance related issues.

Similar to disaster management, there are two phases in drought management too, the planning phase and responding phase. The pre-disaster planning activities include:

- Development of a national drought hazard map showing all the vulnerable areas
- Development of a drought risk map
- Development of a national drought mitigation plan
- Establish forecasting and early warning mechanisms
- Establish drought monitoring systems
- Preparedness for response

Drought response activities include:

- Issuing early warning to pre identified organizations, district and divisional secretariats, people living in vulnerable areas etc
- Monitoring of drought situations
- Responding to disaster situation by providing essential relief such as water, food etc

Future Drought Management Strategies

Even though drought is one of the biggest disasters occurring in the country, currently there is no comprehensive national policy or plan over the management of drought. Unlike other disasters prevailing in Sri Lanka, causes and consequences of drought are very complex and has a long term impact on socio economic and political environment. Therefore to mitigate the drought in a sustainable manner, and to manage droughts, a holistic and coordinated approach should be established.

As the drought has different characteristics, it is required to involve all key agencies essentially Meteorological Department, Irrigation Department, Agricultural Department, Agrarian Services Department etc with inputs from their technical experts in the field. Even though there are various government agencies to work on different technical issues that has bearings on the drought and its impacts such as water supply, irrigation, resettlements, agriculture, crop research, agrarian development, social services and relief distribution, no single agency is capable of developing and implementing strategies to counter the impacts of drought. Above mentioned government agencies are capable of managing their mandates but due to various resource and legislative limitations, they are not in a position to initiate a coordinated approach towards mitigating drought impacts.

Under the prevailing resource limited context of the country, it is not advisable to create a new agency for managing drought and its impacts as it will not be sustainable in the long run. This situation allows only one option available to mobilize the necessary resources to manage drought conditions and that is to strengthen one responsible organization to coordinate all the relevant stakeholders to develop and implement holistic drought management strategy.

The Disaster Management Centre (DMC) established in 2005 August after the 2004 tsunami, has the mandate to coordinate all relevant agencies related to disaster management. As evident in managing the National Disaster Management Coordination Committee and many other collaborative efforts involving many technical agencies in the country, DMC has the experience and confidence to manage efforts of multi disciplinary nature.

Comprehensive drought management strategy may comprise of short term and long term approaches for managing the impacts of drought. Short term approaches may deal with developing drought risk profiles for the country, developing effective and efficient drought relief systems in line with the national development programmes and strengthening risk spreading mechanisms such as crop and livestock insurance.

Long term drought management strategies may include developing sustainable irrigation and domestic water supply schemes, improving drought and crop forecasting systems, rehabilitate the existing tank cascade systems, renovating the abandoned village tanks, ground water recharging mechanisms, promoting water conservation practices, responsible management of water resources for the benefit of public, providing impetus for attitudinal change of public towards conservation and using efficient irrigation systems and above all providing the enabling environment –legislative and institutional- for resource mobilization for drought risk reduction.

Disaster Management Centre as the apex body for coordinating disaster management activities in Sri Lanka can play the role of the coordinator for developing the National Drought Management Policy and National Drought Management Plan. A committee of technical experts can involve in developing the National Policy and Plan with the corporation from all relevant government organizations.

The DMC will base its future drought risk reduction programmes on the Drought Risk Management Strategy and the Action Plan developed through this initiative. Furthermore the recommendations of the initiative will be shared with the members of the National Disaster Management Coordination Committee (NDMCC).

Drought Management Strategy Development Committee of Technical Experts shall;

- Review the existing government policies and governance structures for drought risk reduction related to the agriculture, water, health and sanitation, food security, land use, power & energy and settlements planning.

- Review the impacts of proposed key socio economic development programmes of the country and possible Climate Change impacts on Sri Lanka
- Develop National Drought Risk Management Strategy addressing following areas with the objective of reducing the vulnerability of communities living in drought prone areas;
  - » Livelihood and economic development
  - » Education and skills development
  - » Development of health and sanitation
  - » Communication for encouraging adaptations of best practices
  - » Promotion of farmer based research
  - » Financial risk management mechanisms
  - » Strengthening of bargaining powers of drought affected communities
  - » Increasing disaster resilience
  - » Private public partnerships for risk mitigation
  - » Ecosystem management in drought prone areas

- In addition to the issues directly related to the communities living in drought prone areas of the country, national development priorities established through following documents also should take into consideration in developing the Strategy.
  - » Mahinda Chinthana-Vision for Future
  - » 2030 Infrastructure Development Plan proposed by National Physical Planning Department
  - » Drought hazard profile and other multiple hazard profiles of the country where available
  - » National Action Plan for Haritha Lanka Programme
  - » National Disaster Management Policy and the National Disaster Management Plan of Sri Lanka
  - » Draft Land Use Policy of Sri Lanka
  - » Millennium Development Goals
  - » Research papers submitted by various professionals on management of drought in Sri Lanka

The technical expert committee should consist of following members from different organizations for different purposes as listed below.

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NOTES

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